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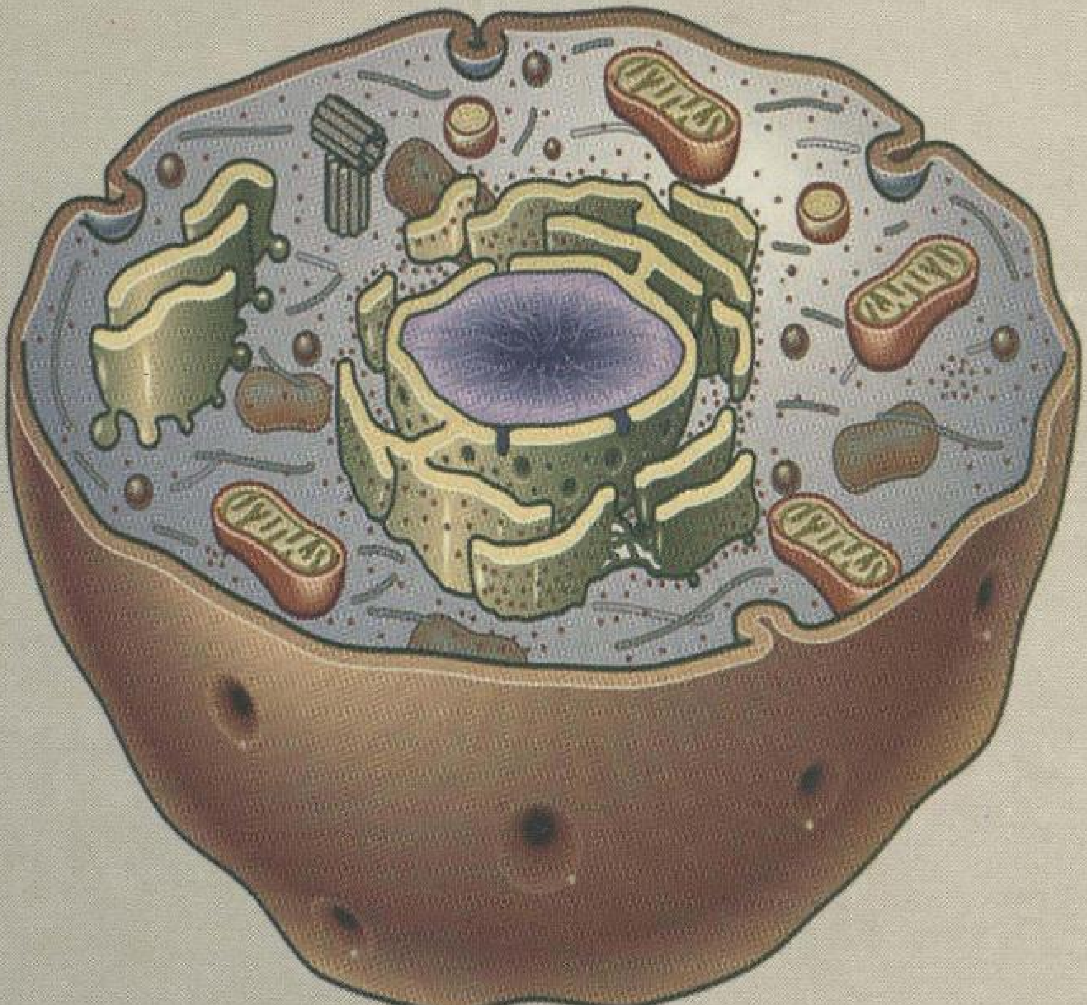

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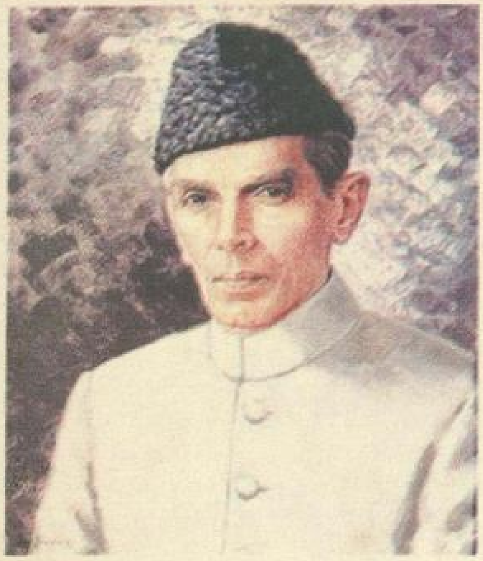

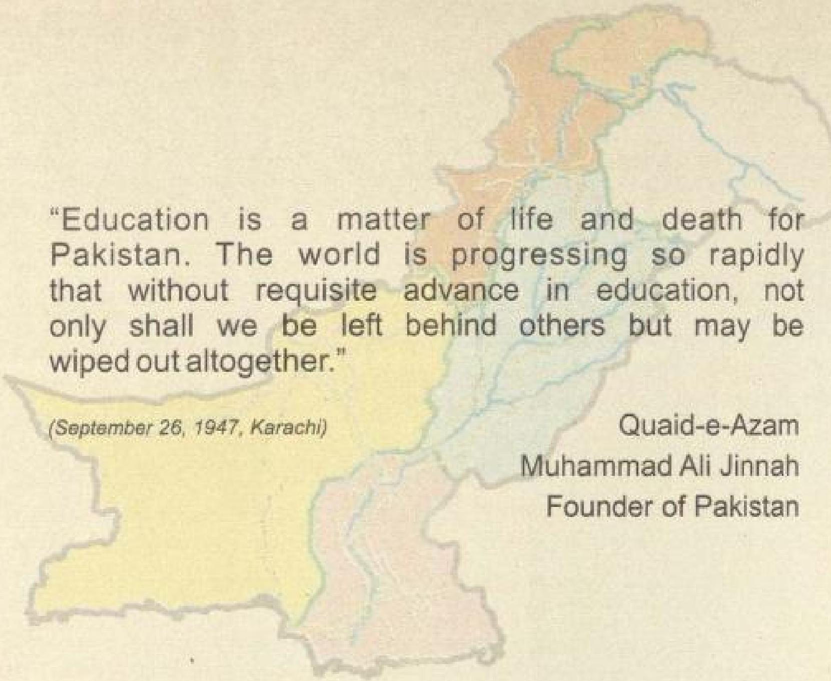

"Education is a matter of life and death for Pakistan. The world is progressing so rapidly that without requisite advance in education, not only shall we be left behind others but may be wiped out altogether."

(September 26, 1947, Karachi)

Quaid-e-Azam
Muhammad Ali Jinnah
Founder of Pakistan

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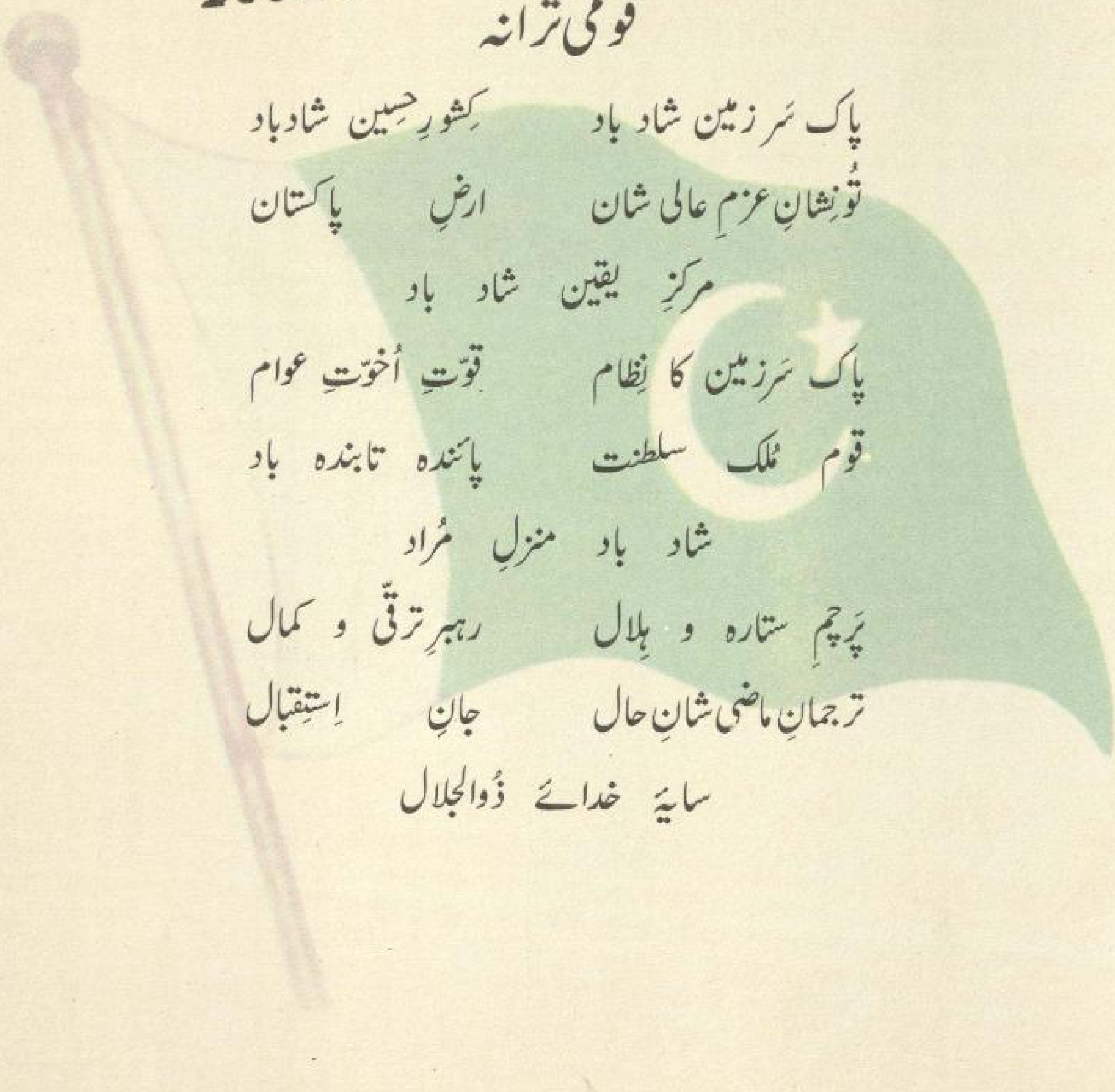

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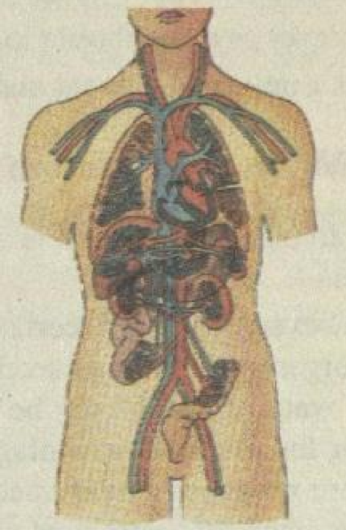
Published by: Punjab Text book board lahore.
Printed by: Malik Siraj din & Sons

Date of Printing	Qty.
May 2010	10,000

TRANSPORT IN LIVING ORGANISMS

In this chapter you will learn:
- Importance of water to life.
- Processes involved in transport of material across the cell, diffusion, active transport and osmosis.
- Turgor and its importance in plants.
- Transport of water and salts in plants
- Transpiration and factors affecting it.
- Path of organic material in plants.
- Open and closed circulatory system of animals and circulatory system of man.
- Blood groups and Blood diseases.



In all living organisms plants and animals, physiological processes are continually taking place in their bodies. In order to sustain life, these processes must be kept going on for which the materials required, must be constantly transported to and from all parts of the body right down to the individual cells. Materials are also to be transported between the cell organism and external environment. In unicellular and simple multicellular organisms, the distribution of materials can be adequately brought about by diffusion and streaming movements of the cytoplasm (Fig. 12.1).

However, the evolution of more and more complex body structures necessitated the development of proper transport system, and more complex the organisms are, the more elaborate transport system they have. The complexity of transport system is related to the size and the metabolic rate of the living organism.

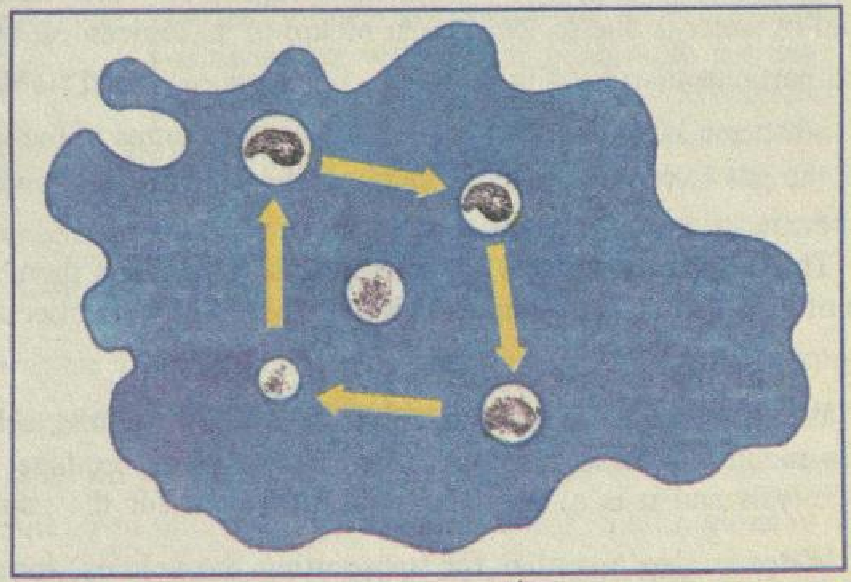


Fig. 12.1 Streaming movement of cytoplasm (in *Amoeba*)

The materials to be transported are taken close to tissues by the transport system so that diffusion can occur efficiently into the cells. The primary function of the transport system is to maintain a link between all cells of the body and the external environment. It transports the nutrients to the points where they are to be used, facilitates the elimination of metabolic wastes of each cell and transports surplus substances to the specialized storage tissues or to out side their bodies.

12.1 Importance of Water to Life

Water is an extra-ordinary compound. It is the only substance that occurs in nature in three phases i.e. solid, liquid and vapour, within the normal range of earth's temperature.

Water is of extreme importance to living organisms. It plays an important role in the sustenance of life as:

(i) It is an important active constituent of the living matter, the protoplasm.
(ii) It serves as a metabolite in many metabolic processes.
(iii) It is a universal solvent and a medium of transport.

12.1.1 Water as a Component of Cell

In living cells, water is invariably present. It normally constitutes 85-90 percent of the protoplasm.

However, there are certain structures produced by living organisms, such as seeds, spores, cysts etc. in which the water content may be as low as 10 percent. The reason for the low percentage of water in them is that they are produced under special conditions and are meant for special purpose i.e. reproduction or perennation. They have a very low physiological activity rate, which does not require much water.

Water is present within the cells and also bathes the cells, all around within the body of the organism.

> Do you know that the existence of life on our earth is due to the presence of water. If there were no water, life would not have originated or evolved on our earth; no water, no life. Water is not everywhere, but wherever there is water, there is life.

12.1.2 Water as a Solvent

Water is an excellent solvent for the substances, which are very important to all processes of life. The salts dissolve to a much greater degree in water than in any other solvent. The solvent potential of water is due to the dipolar nature of its molecules, which causes it to orient itself around charged particles dissolved in it. When, for instance, NaCl (table salt) is dissolved in water, its Na^+ and Cl^- disperse as independent ions. The negative zones of the water dipoles will arrange themselves around the positively charged Na^+ ions, while the positive zones of the water molecules will do so around the negatively charged Cl^- ions.

This alignment of the salt ions in this way keeps them separated and thus promotes a high degree of dissociation. Substances, when dissolved in water, become chemically reactive.

12.1.3 Water as a Metabolite

Water acts as metabolite as all the chemical reactions, occurring in the cells, take place in an aqueous medium. Those reactions often consume or produce water molecules. Water is required for hydrolysis and it is also an essential ingredient for the manufacture of food by photosynthesis.

Water is also essential for transporting the solutes, for cooling the plants and animals (by evaporation from their surface), and for developing the internal pressure that provides support and rigidity to the bodies of plants and many animals.

In fact, the life that exists on our earth would not have originated and evolved if there had been no water. The maintenance of constant aqueous internal environment is a principal physiological requirement for all terrestrial as well as aquatic organisms.

12.2 Transport of the Materials across the Cells

In the living organisms, each cell is bounded by cell membrane. The cell membranes are able to regulate the movement of materials across them.

The cells constantly exchange materials with their environment through the cell membranes. But the movement of materials, in and out of the cells, across the cell membranes is not an uncontrolled traffic, because certain materials can pass through the membrane, others cannot. Thus the primary function of the cell membranes is to regulate the passage of substances between the interior of the cell and its external environment.

Many different molecules can move across the cell membrane. Of all these, water is the most important one. Many inorganic salts can move across the cell membrane in solution i.e. dissolved in water. One of the processes by which the exchange of materials between the cells and their environment occurs is called **diffusion**. For instance, water and inorganic salts dissolved in it pass into the plants by diffusion through the root hairs into the cells of the roots.

12.2.1 Diffusion

It is a process in which the random movement of the molecules or ions takes place down a concentration gradient i.e. from region of higher concentration to a region of lower concentration. Water, CO_2 , O_2 and some other simple molecules can diffuse across the cell-membranes in this way. It is also the main process by which other substances move within the cells. During photosynthesis and respiration in the plants, the exchange of carbon dioxide and oxygen gas, between the cell and the atmosphere also takes place by diffusion. Although diffusion is a slow process, yet it is efficient and rapid enough to fulfill all the gaseous requirements of the plant.

The molecules of some substance because of their size or polarity cannot pass readily, into and out of the cell through the cell membrane. This is brought about by certain proteins called carrier proteins. But here too the movement would be according to the principle of concentration gradient i.e. from higher to lower concentration area. This type of diffusion which takes place with the help of carrier proteins, is called **facilitated diffusion.** Like simple diffusion, in this case also expenditure of energy is not involved.

Diffusion is a well known phenomenon. It can be clearly demonstrated by a simple example i.e. when a coloured crystal like ($KMnO_4$) is dropped into a bowl of water, initially the color or pigment will remain concentrated at its initial drop area. Gradually its molecules will diffuse evenly in all directions throughout the water, resulting in uniform distribution of color in all regions of the water in the bowl (Fig. 12.2). Similarly, if we spray perfume (air-freshener) in one corner of a room, initially its fragrance will be strongest in that corner and will gradually spread by diffusion in all areas of the room.

The efficiency of diffusion depends on two factors, (a) a distance (b) a concentration gradient difference. The speed of diffusion also depends on the kind of molecules, e.g., diffusion of gases is faster than of liquids; and similarly the diffusion of solids is the slowest.

Diffusion plays a key role in the transport of substances into and out of cell in all living organisms.

12.2.2 Active Transport

Sometimes the movement of substances across the cell-membrane takes place against the concentration gradient (uphill movement) i.e. from a region of lower concentration to a region of higher concentration. This type of uphill movement of substances requires the expenditure of energy and is called **active transport**.

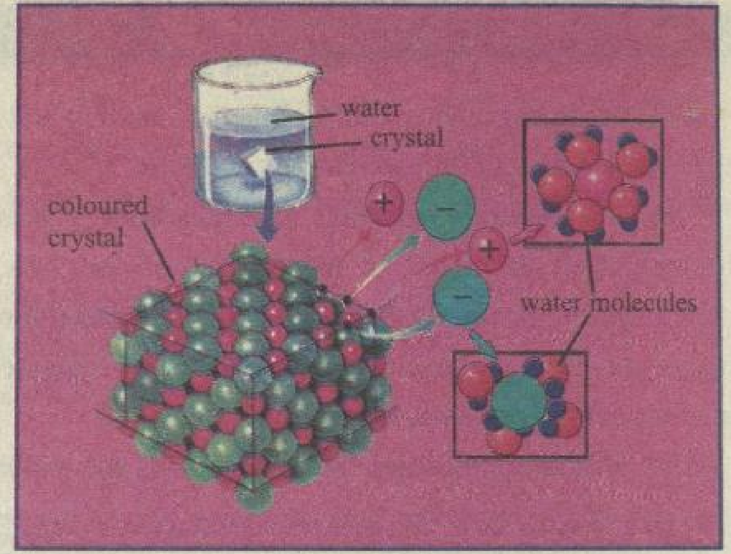


Fig. 12.2. The Process of Diffusion

12.2.3 Osmosis

As you all know that a living cell is enclosed in the cell membrane, which allows some substances to pass through it but prevents the passage of others. Such membrane, which is selective in the passage of substances, is called a **selectively permeable** or **differentially permeable membrane**. The solvent molecules, which in most cases are water molecules can readily pass through the cell membrane. The water molecules can easily diffuse through the cell membrane. The movement of water (solvent) through a differentially permeable membrane is a special kind of diffusion called **osmosis**.

Practical Work: To Demonstrate Osmosis

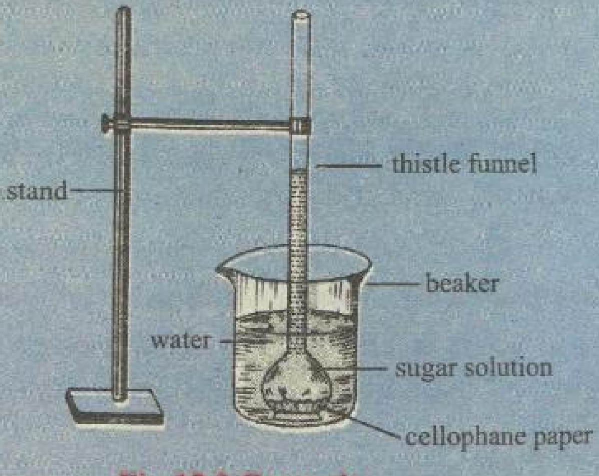


Fig 12.3 Osmosis

Take a thistle funnel and tie a cellophane or egg membrane (both are differentially permeable) around the wide end or the mouth of the funnel. These two membranes are permeable to water molecules but not to dissolved solute molecules such as source (sugar).

Fill the thistle funnel, upto a marked level with concentrated sugar solution and place the funnel, with its mouth end immersed in water. You will see that the water would move both into and out of the funnel. But because of the greater water concentration outside the funnel, the movement of water into the funnel would be more rapid than its movement to the outside of the funnel into the beaker. Consequently, the level of sugar solution will rise in the tube of the funnel. As the movement of water into the funnel goes on, the sugar solution in the funnel will become more and more dilute. The movement of water molecules into the funnel was the quickest at the time when it was first immersed into the beaker because at that time there was a concentration gradient greater difference between the water in the beaker and the sugar solution in the funnel. At that time, the movement of water out of the funnel was the slowest . The movement of water into and out of the funnel went on until the equilibrium of water molecules on both sides of the membrane was reached .

12.2.4 Turgor

If a cell is surrounded by water or a solution more dilute than its contents (i.e. having lesser concentration of solutes and higher concentration of water), the water tends to move into a cell vacuole by osmosis. As the water enters the vacuole, it increases in size and pushes the cell contents against the wall. The plant cell does not burst as the cell wall is fairly strong and relatively inelastic. However, the cell wall cannot expand beyond a certain limit. The cell wall, thus prevents over-expansion of the cell by exerting an inwardly directed or an opposing pressure which prevents the entry of more water into the cell. The cell in this state becomes **turgid**. The condition thus produced in the cell is called **turgor** and the internal pressure exerted on the cell wall is called **turgor pressure** (Fig. 12.4a).

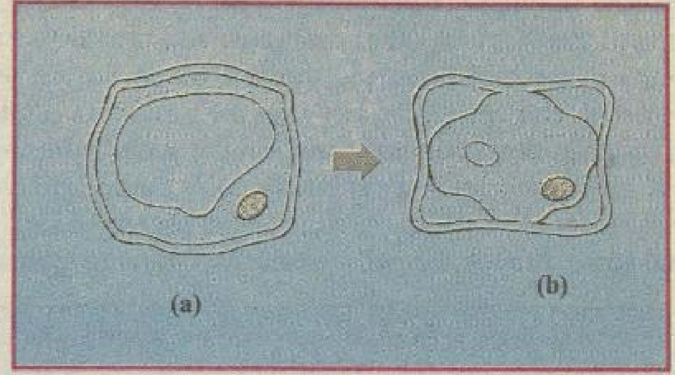


Fig 12.4 (a) A turgid plant cell,
(b) The cell begins to become flaccid and wilt

When all the cells in a leaf and stem are turgid, the plant structures like leaves and young branches will be stiff, firm and upright. If the cells some how lose water, the cell will lose turgor and will become **flaccid** (soft and limp). The leaves with flaccid cells become limp and the stem droops. Thus plant cells with reduced turgor due to loss of water is said to be **wilting** (Fig. 12.4b).

Importance of Turgor in Plants

Turgor plays an important role in maintaining the shape of the soft tissues in plants. The movements of certain plant parts also result from the changes in their turgor e.g., changes in the turgor of the guard cells of the stomata cause the opening and closing of the stomata. Some flowers open during the day time and close at night or vice versa. In these the bending movements of their petals is due to changes in turgidity of the cells. The closing of leaves of some plants e.g. touch-me-not, is also due to turgor changes in the leaf-lets.

12.3 Transport of Water and Salts

Most of the gymnosperms and dicots lack vessels; instead they have tracheids. Each tracheid is an elongated, dead cell with lignified walls, and intact end walls.

The plants have two types of vascular tissues, namely the xylem and the phloem. The xylem tissue transports water and the dissolved minerals (inorganic salts) from the roots upwards to the stems and the leaves.

The end walls between the vessel element are broken down so that they form continuous, uninterrupted tubes, allowing water to be easily conducted upwards mainly due to transpiration pull, which is discussed later in this chapter.

12.3.1 Uptake of Water and Minerals by Roots

Water with dissolved salts enters the plants from the soil through the roots and is then transported to all parts of the plant by xylem. The root hairs, arising just behind the root tip, are outgrowths of the epidermal cells of the root. They enormously increase the surface area for the absorption of water and salts.

The mineral salts are dissolved in the soil water. Much of the water and minerals that enters the root is taken up through the root hairs (Fig. 12.6). The sap water alongwith dissolved substances moving through the plant or present in the vacuole of the root contains a strong solution of solutes (sugars and various other inorganic and organic salts). Thus a concentration gradient is established between the root hairs and the soil water. So the water from the soil moves into the root hairs by osmosis. The entry of water into the root hairs dilutes its sap. Now the sap of the root hair is more dilute than that of the next cell. So the water from the root hair moves into root cells. The water from the epidermal cells then passes into the xylem vessels and ascends up the stem. This upward movement of water and salts is called **ascent of sap**. Some water travels upwards along the cell walls and some through the cells themselves moving from one cell to another.

Practical Work: To demonstrate the ascent of sap in plants

Take a medium-sized herbaceous potted plant. Uproot it and place it in a beaker containing red, eosin solution. The roots must be completely submerged in the dye solution. Let the plant stay in the solution for about half an hour. Now cut transverse sections of the stem and leaves from the part of the plant that was out of the eosin solution. Examine the sections under the microscope. You will observe that xylem portions of vascular bundles would have become red by the eosin in the plant. This indicates that water is conducted upward through the xylem vessels in the different organs (Fig. 12.5).

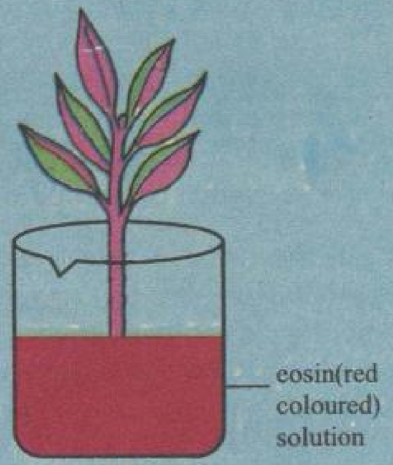


Fig 12.5. Apparatus showing ascent of sap.

12.4 Transpiration

The xylem vessels of tall trees transport abundant water from the roots to the leaves situated a height of several meters. What is the force that causes this movement?

Water is the major constituent of plant tissues. The plants absorb large amounts of water from the soil. Of the water absorbed from the soil, only a small proportion of it is retained by the plants while the rest of it is passed off into the atmosphere without being involved in any metabolic activity of the plants, mostly by the process of transpiration.

The water absorbed by the roots from the soil enters the root xylem vessels which take it to the leaves. In the leaves, the water leaves the xylem and is distributed to all cells of the leaves but a major percentage of it evaporates from the leaf surface into the atmosphere. So, transpiration can be defined as "the loss of water by evaporation from the aerial parts(cells) of the plant, especially through the stomata of the leaves". As a consequence of loss of water by transpiration, plants require large amounts of water for their survival.

Some of the water entering the leaves diffuses into the cells of the mesophyll tissue of the leaves through their cellulose cell walls (as cellulose is freely permeable to water). The mesophyll cells are in contact with the air-spaces in the leaf. The water from the cells of the mesophyll diffuses through their walls into the intercellular spaces from where it evaporates and diffuses into the atmosphere through the stomata. The evaporation of water from the top of the leaf reduces the concentration of water but increases the concentration of solutes in the leaf cells. So because of higher osmotic pressure in the leaf cells, more water enters the leaf cells form the xylem. The uptake of water from the top of the xylem, lowers the hydrostatic pressure at upper region of the xylem vessels. Whereas at base of the vessels, this pressure is very high. This difference in the pressure at the base and the top of the xylem vessels produces a pull or tension which pulls the water from the area of high pressure (lower xylem) to the area of low pressure (upper xylem).

The pull or suction force thus produced in the xylem vessels by the evaporation of water (transpiration) from the leaf is called **transpiration pull**. As a consequence of the transpiration pull and the cohesion and adhesion of water molecules, the water moves up the xylem vessels as an unbroken column called the **transpiration stream**. The xylem vessels are a continuous system of tubes from the roots, to the stem and the leaves (Fig 12.6).

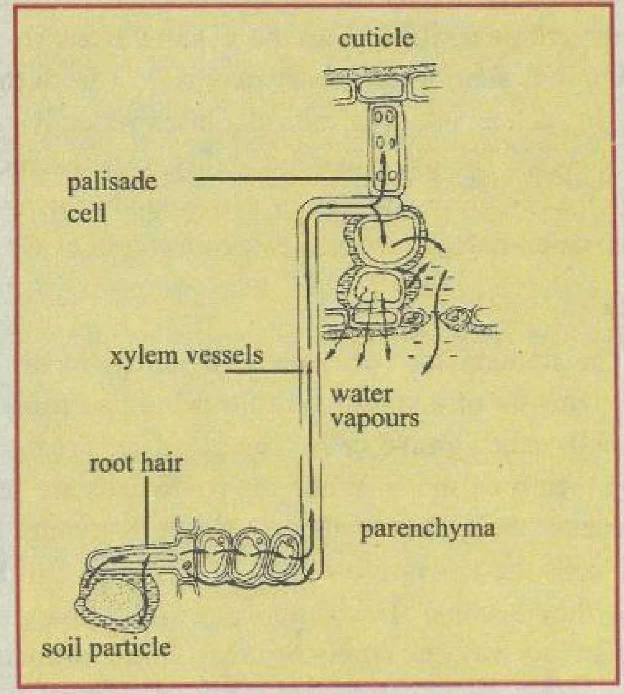


Fig. 12.6. The transpiration stream

12.4.1 Factors Affecting the Rate of Transpiration

The rate of transpiration depends on some environmental factors; such as temperature, wind, humidity, light, atmospheric pressure etc.

(i) Temperature and wind

The temperature greatly affects the rate of transpiration. When the temperature is high, rate of evaporation increases, the water molecules move rapidly than at low temperatures and also because warm air can hold more water vapours than the cold air. So, on a warm day the rate of transpiration increases. Windy condition also increase the rate of transpiration as wind removes water vapours from around the leaf and keep the concentration difference high between the leaf and surrounding air.

(ii) Humidity

In nearly dry condition or low humidity, the air around the plant will be dry, it will have low concentration of water than that inside the leaves. This difference in the concentration of water would result in an increase in the rate of transpiration. When there is more humidity in air, transpiration would be considerably low, as the air is already saturated with water vapours and it will not be able to absorb more water. So, under such a condition very little water will diffuse out of the leaves.

(iii) Light

Light is an important factor in controlling the rate of transpiration as it greatly influences the opening and closing of stomata of leaves. During day-light, the stomata remain open and allow the water vapours from the leaves to diffuse out into the atmosphere. At night or during hours of darkness, the stomata usually close, and the rate of transpiration is greatly reduced or it may even stop completely.

(iv) Atmospheric pressure

The atmospheric pressure also affects the rate of transpiration. Reduction in the atmospheric pressure enhances the rate of transpiration.

12.4.2 Importance of Transpiration

Transpiration plays an important role in the life of plants as it provides the forces or tension to pull water and minerals ions up the xylem vessels from the roots to the leaves. Sometimes, when the water supply is short, more water may be lost from the plants by transpiration than is absorbed from the soil. In such a condition the cells loses water. As a result of this, the plant loses their turgor and become flaccid. The plant has the ability to withstand such a condition if it lasts for a short period. But if such a condition persists for long periods, the plant wilts and even dies. In such conditions many plants have ability to control the rate of transpiration by closing their stomata.

Stomata

The stomata are very minute openings in the epidermis of the leaves. A stoma (singular of stomata) consists of a small central opening surrounded by a pair of modified epidermal, sausage-shaped, cells called **guard cells**. The guard cells regulate or control the size of the stomal opening, by changing their own shape. When the guard cells are turgid, their inner margins curve apart from each other because their inner walls are thicker than outer ones. Thus by the curving of the inner margins of guard cells the aperture between them opens. On the other hand, when the guard cells loose their turgidity, they become flaccid and their inner margins become straightened and come to lie close together. In this way, the stoma is closed. If the stomata are closed, transpiration is almost completely stopped.

12.4.3 Measurement of the Rate of Transpiration

The rate of transpiration can be measured by many methods. It is generally believed that the rate of absorption of water from the soil is nearly equal to the rate of transpiration. Of the many methods for the measurement of the rate of transpiration, one makes use of potometer, a glass apparatus that works on above-mentioned principle.

Practical Work: Comparison of the rate of transpiration by potometer

Take a leaf shoot and fix it in one of the arm of a thoroughly water-filled potometer (Fig. 12.7). If there are any air bubbles, these should be excluded. All connection, should be made air tight with the help of vaseline or plaster of Paris. Now introduce the air bubble into the capillary tube of the apparatus. Place the setup at a well-lit place. As soon as the transpiration starts, the air bubble will begin to move along the capillary tube, the rate of movement of the air bubble gives the measure of transpiration. Rate of transpiration can be compared under different condition such as light/shade; under the fan/away from fan etc.

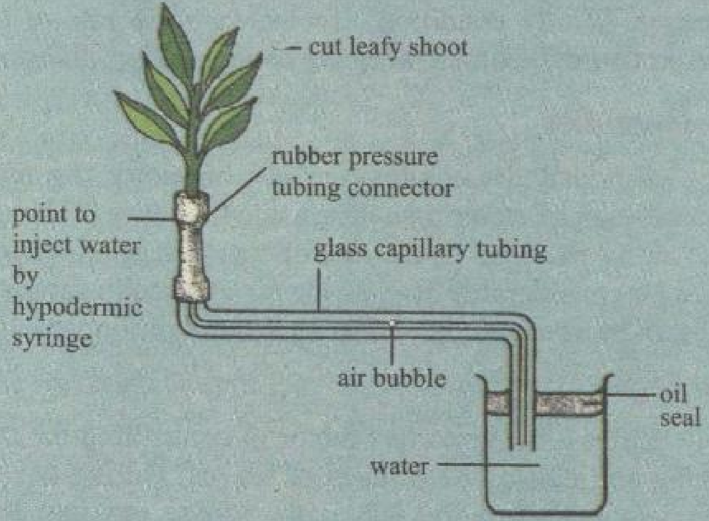

cut leafy shoot
rubber pressure tubing connector
point to inject water by hypodermic syringe
glass capillary tubing
air bubble
oil seal
water

Fig 12.7. Water potometer for measuring the rate of transpiration.

Practical Work: Comparison of transpiration from two surfaces of leaf by cobalt paper

The lower surface of the leaf has more stomata than the upper surface, so more water transpires from the lower surface than the upper surface. This can be demonstrated by the **cobalt chloride method**. In this method the amount of transpiration of water is estimated by the change in colour of the cobalt chloride paper. When dried cobalt chloride paper is exposed to humid air or moisture it will gradually change its colour from blue to pink. The normal colour of dry (anhydrous) cobalt chloride paper is blue. The cobalt chloride paper can be prepared by treating filter paper disc with 3% slightly acidic solution of cobalt chloride. After treatment the filter paper discs are thoroughly dried. In order to perform this experiment, take two equal sized discs of blue cobalt chloride filter papers. Place one disc on the upper and one on the lower surface of the leaf of a potted plant. You will see that after a few minutes, the cobalt chloride paper starts changing colour from blue to pink. You will note that the paper fixed on the upper surface of the leaf takes much longer time to turn pink from blue than that of the paper on the lower surface of the leaf. The rate of change of colour indicates the rate of transpiration, which is much higher from the lower surface than from the upper surface. This is because of the presence of stomata on the lower surface (Fig. 12.8).

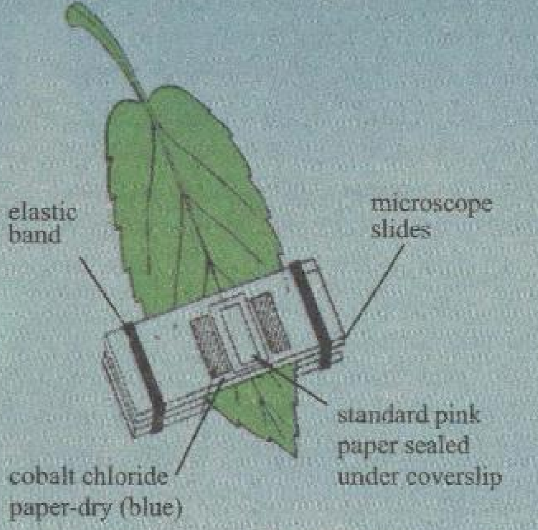

elastic band
microscope slides
standard pink paper sealed under coverslip
cobalt chloride paper-dry (blue)

Fig 12.8. Cobalt chloride paper

12.5 Path of Transport of Organic Materials in Plants

The green plants manufacture food in the leaves. From the leaves, the sugars need to be moved to the non-photosynthetic parts of the plants such as roots, stems and flowers for storage or consumption.

The manufactured food substances (sugars) are transported from the leaves to the other parts of the plant body by phloem tissue (mainly sieve tubes) as its structure is well suited for this function.

The transport of carbohydrates, mostly in the form of sucrose (sugar), from the leaves to all other parts of the plant is called **translocation**. In addition to sugars, the phloem also transports amino acids, growth hormones, and vitamins.

The mechanism of the translocation of these substances through the sieve tube cells of the phloem is not yet clearly understood. Several hypotheses have been proposed to explain this mechanism. One of these hypotheses is the **mass flow hypothesis** (Fig. 12.9). Many plant physiologists favour this hypothesis.

According to the mass flow hypothesis, the sugars in solution can move freely through the sieve tubes from the leaves to all non-photosynthetic parts of the plants. This movement is because of the difference in the concentration gradient at the place of manufacture of sugar i.e., the leaves and the other parts of the plant which need nourishment to carry out their activities. As the food is manufactured in the leaves, the sieve-tubes in their veins are loaded with sugar. More water therefore enters then by osmosis. Consequently they have a high sugar pressure. Other parts of the plant have low concentration of sugar and consequently low sugar pressure. So the sugar will move from a region of high concentration(source) to the region of low concentration(sink).

The phloem stream, carrying the manufactured food, moves in the direction opposite to that of the transpiration stream. One objection against the mass flow hypothesis is that the phloem often transports substances in the opposite direction too i.e., up the stem to provide nourishment and energy to the leaves and shoots for their growth and also to the developing seeds and fruits. But this objection to the mass flow hypothesis does not hold good if we recall the structures of the phloem tissue. The phloem tissue consists of many sieve tubes, not just one, and the fluids can move in opposite direction in two different but closely situated sieve-tubes. Here too, the movement of fluids in opposite direction would also depend on opposing pressure gradients in the two ends of the sieve-tubes.

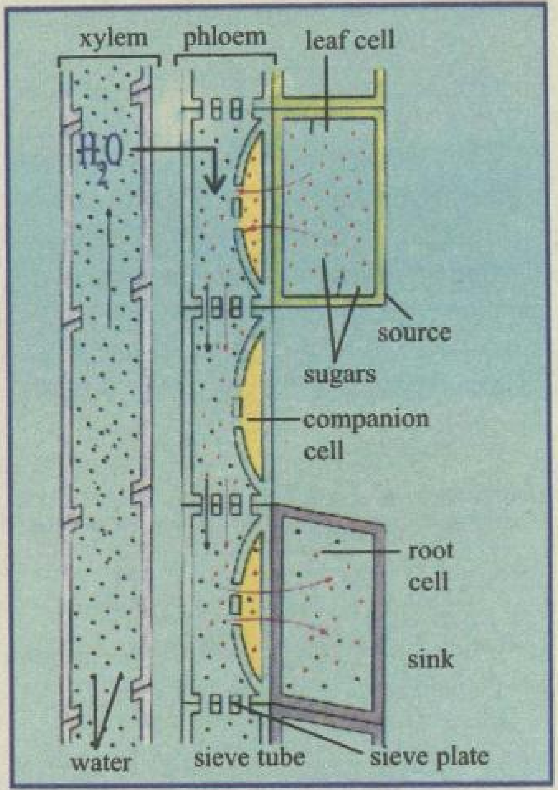


Fig. 12.9 Pressure flow hypothesis.

12.6 Transport in Animals

As you have already learned that in all living beings the nutrients and gases are transported to and from all parts of the body. This is essential to carry on various life processes. In case of unicellular and small multicellular organisms transport takes place by diffusion. However, in large multicellular organisms, as the distances between different body parts have increased, they need an elaborate and efficient system for transportation of materials. In large animals, such a system is called **circulatory system** in which a fluid circulates in all parts of the body. In many invertebrates this fluid is the **haemolymph**, whereas in all vertebrates and in some higher invertebrates this fluid is the blood.

The circulatory system in animals is of two main types (A) open circulatory system and (B) closed circulatory system.

(A) Open Circulatory System

Many invertebrates e.g. arthropods have open circulatory system [Fig 12.10(a)]. In this system the blood is pumped from the heart into the blood vessel. The blood vessels in turn, empty themselves into open spaces called **sinuses**. In the sinuses, the blood is in direct contact with the tissues, and after exchange of materials with the tissues it re-enters the heart for circulation again.

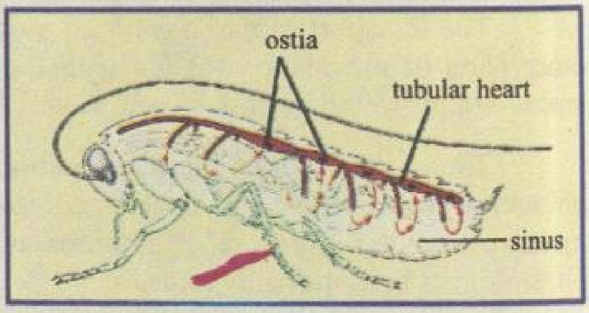


Fig. 12.10(a) Circulatory system in insect

(B) Closed Circulatory System

Closed circulatory system is more elaborate, complicated and efficient as compared to the open circulatory system. The closed circulatory system consists of a muscular, and contractile pumping organ, the heart with its incoming (veins) and outgoing (arteries) blood vessels. The blood remains confined in the blood vessels while circulating in the whole body e.g. earthworm, man etc.

In closed circulatory system, the heart pumps blood into the blood vessels (arteries) which take away the blood from the heart to the tissue. In the tissues, the arteries divide and subdivide into very fine branches, called the capillaries. The walls of capillaries are just one cells thick, and in them the blood is in close contact with the tissue cells. Exchange of materials with tissues is carried out here. The capillaries join and form bigger blood blood vessels called venules. These venules in turn join to form the veins, which ultimately transport blood back to the heart. (Fig. 12.10 - b)

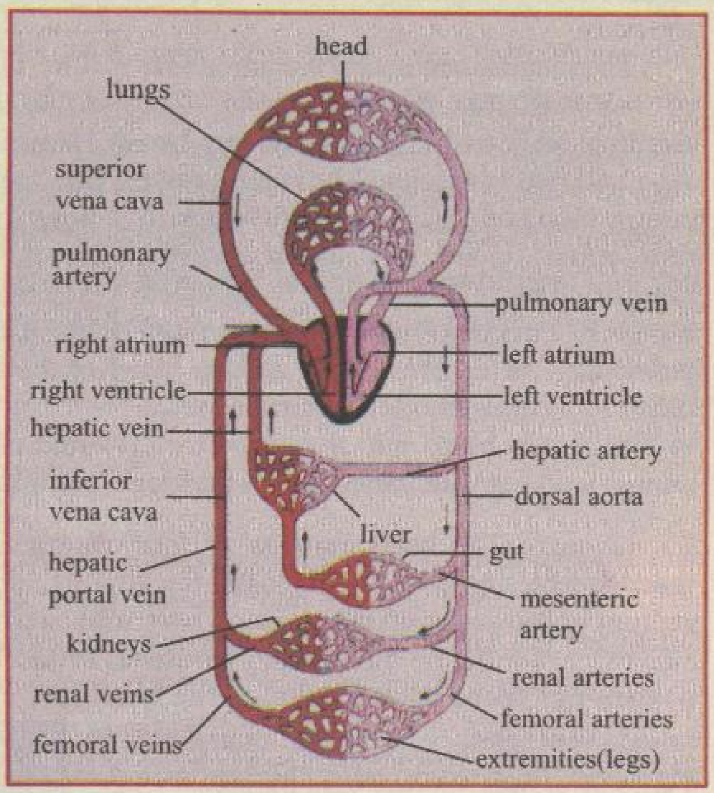

head
lungs
superior vena cava
pulmonary artery
pulmonary vein
right atrium
left atrium
right ventricle
left ventricle
hepatic vein
hepatic artery
inferior vena cava
dorsal aorta
liver
gut
hepatic portal vein
mesenteric artery
kidneys
renal arteries
renal veins
femoral arteries
femoral veins
extremities(legs)

Fig. 12.10(b) A general plan of close circulatory system .

12.6.1 General Plan of Circulatory System of Vertebrates

In vertebrates, the circulatory system is always of closed type. The closed circulatory system is further of two types, (a) single circuit circulation, (b) double circuit circulation.

For instance in fishes the circulation is of single type. In it, only the deoxygenated blood circulates through the heart. The deoxygenated or the venous blood from all tissues of the body enters the sinus venous, from where it passes into the single auricle or atrium. From the atrium it goes in the ventricle. From the ventricle, the blood is pumped into the gills for oxygenation. The oxygenated blood from the gills is directly distributed to all parts of the body. As the blood circulates once through the heart, therefore, this type of circulation is called **single circuit circulation.**

In land vertebrates, with the introduction of lung respiration, **double-circuit circulation** evolved. The evolution of double circuit circulation led to the division of atrium and ventricle, each into two chambers. The atrium divided into right and left atria (plural of atrium) and likewise the ventricle also divided into two chambers. In amphibians, the ventricle is not divided and in most reptiles, the division of the ventricle is incomplete. In some reptiles and in all birds and mammals, the division of the ventricle is complete. So in these animals, oxygenated and deoxygenated bloods are completely separated from each other and there is no mixing of these two types of blood. This increases the efficiency of the circulatory system. The circulatory system in vertebrates is highly developed and among them mammals have the most efficient circulatory system.

12.6.2 Human Blood Circulatory System

The human blood circulatory system, like other vertebrates, consists of a heart, a system of of blood vessels and blood. Study it in your class using a model of human heart.

Structure and Action of Heart (Human Heart)

The human heart like other vertebrates is a muscular, contractile structure. The cardiac muscles of the heart are capable of strong contraction which brings about the circulation of blood through out the body.

The mammalian heart (including that of man) is two pumps in one. The mammalian heart has four chambers-two atria and two ventricles. The right atrium pumps blood into right ventricle which in turn pumps blood into the pulmonary arteries. From lungs the oxygenated blood is carried to left atrium through pulmonary vein. From left atrium the blood is pumped into left ventricle which in turn pumps blood into the aorta- the **systemic circulation** (this is pump two). Thus there are two pumps working simultaneously in the single pumping organ-the heart.

The Heart Bag- The Pericardium

Heart is enclosed in a tough, fibrous bag. This bag is the pericardium.Between the pericardium and the heart is a fluid called pericardial fluid which acts as shock absorber and protects the heart from the external shocks. The pericardium is not flexible or extensible. It also probably limits the over-extension of the heart in certain extreme conditions.

The heart consists of four chambers. The upper half of the heart consists of two independent, thin walled chambers, the atria or auricles separated from each other by a partition or septum called **inter atrial** or **inter auricular septum**. The right atrium receives the deoxygenated i.e., oxygen deficient blood from all tissues of the body whereas the left receives the oxygenated or oxygen-rich blood from the lungs. The lower half of the heart consists of two thick walled chambers called ventricles, which are completely separated from each other by an inter-ventricular septum. Ventricles are much larger than the atria and are involved in pumping the blood out of the heart.

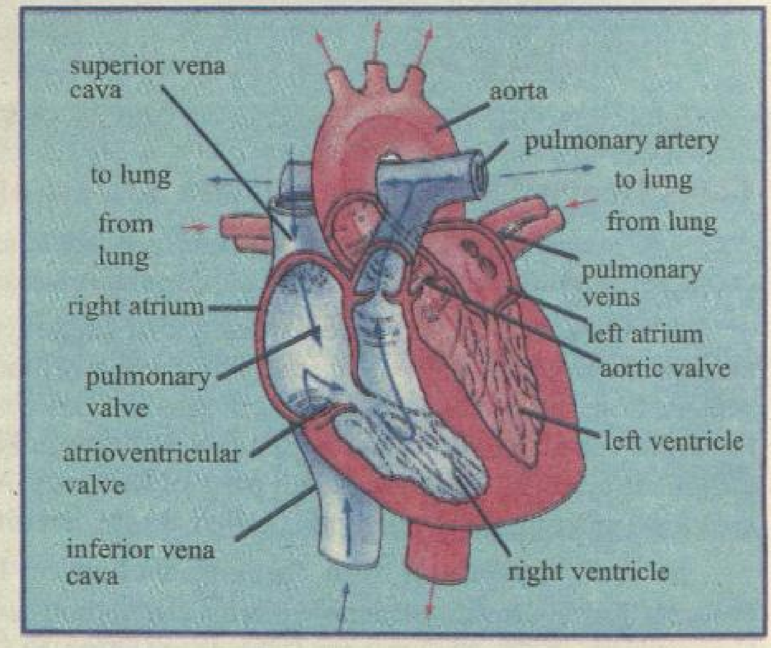


Fig. 12.11 Internal structure of heart and the directions of flow of blood.

The inter-atrial and inter-ventricular septa (singular: septum) prevent the mixing of deoxygenated and oxygenated blood. Each atrium pushes the blood into the ventricle of its side through an atrio-ventricular aperture. The atrio-ventricular apertures are guarded by valves, the atrio-ventricular valves. These are made of almost transparent, thin but very tough flaps of tissue. The right atrio ventricular valve consists of three cup like flaps and is called tricuspid valve, while the left consists of two cup like flaps and is called **bicuspid valve**. The atrio-ventricular valves allow the flow of blood from the atria to the ventricles but at the time of ventricular contraction, they prevent the backward flow of blood from the ventricles to their respective atria (Fig. 12.11).

The two atria contract simultaneously to push blood into ventricle. On the other hand, the ventricles have to contract with a great force as they have to push the blood to the lungs and to the rest of the body. The left ventricle contracts more forcefully than the right one, as it has to push the blood all around the body, while the right one has to push the blood to the lungs which are fairly close to the heart.

Pulmonary Circulation

The left atrium receives oxygenated blood from the lungs through a pair of **pulmonary veins**, which open into the left atrium. From left atrium, the blood flows into the left ventricle. The right atrium which receives deoxygenated blood from all parts of the body, empties itself into the right ventricle. From there the blood is passed into the lungs, for oxygenation, by a pulmonary arch, which divides into two pulmonary arteries, each going to the lung of its own side. The opening of the pulmonary arch and the aorta, into the left and the right ventricles respectively are guarded by two semilunar valves. At the time of contraction of ventricles, semilunar valves allow the blood to enter the pulmonary arch and the aorta and when the ventricles relax, prevent its backward flow into the ventricles. This part of the circulatory system is called pulmonary circulation. It must by noted that in pulmonary circuit, the pulmonary arteries carry the deoxygenated blood. While the pulmonary veins carry the oxygenated blood.

Systemic Circulation

From the left ventricle the systemic arch or the aorta originates. The aorta distributes the oxygenated blood to all parts of the body through a number of blood vessels (arteries). Near the proximal region of the aorta, arise the carotid arteries which supply blood to the head and the face. A pair of subclavian arteries from the aorta supplies blood to the shoulder region and the arms.

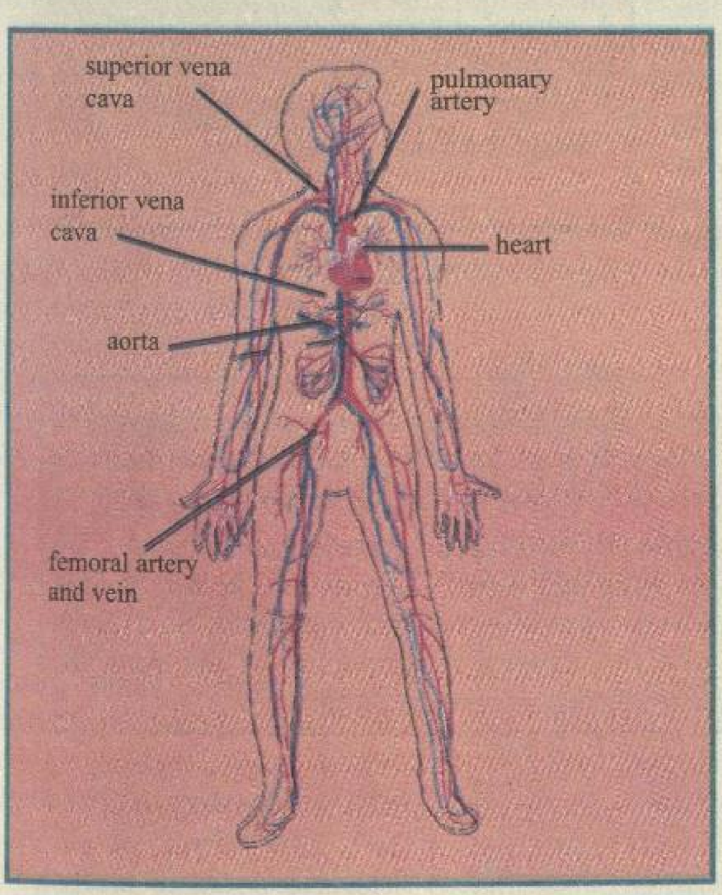


Fig. 12.12 Blood Circulation in Man

The alternating contraction and relaxation of the heart chambers is called the cardiac cycle. The two atria contract simultaneously emptying blood into ventricles. A fraction of a second later, the two ventricles contract simultaneously forcing blood into arteries leaving the heart. Both the ventricles then relax briefly before the cycle is repeated. The period of ventricular contraction is called **systole** and their relaxation is called **diastole**.

In mammals (including man) the heart receives its blood supply through a pair of coronary arteries which arise from the aorta close to its origin. The coronary arteries break up into an extensive network of capillaries surrounding the cardiac muscles and provide them the oxygen and the nutrient.

In the region of the liver, the aorta gives off a hepatic artery which supplies the oxygenated blood to the lobes of the liver. The kidneys receive their blood supply through a pair of renal arteries arising from the aorta. In the gut region, the aorta gives off a mesenteric artery to supply blood to the digestive tract (Fig 12.12).

The deoxygenated blood from the head and the shoulder region is collected by jugular and subclavian veins which join together to form a large vein, the superior vena cava. The superior vena cava pours its blood into the right atrium. From the hind limbs, the deoxygenated blood is collected by a pair of iliac veins , which join together to form the inferior vena cava. The inferior vena cava on its way forward towards the heart receives a pair of renal veins. The deoxygenated blood from digestive tract is collected by a number of veins which join together to form the hepatic portal vein, which opens into the liver and pours its blood there. From the liver, the deoxygenated blood is collected by a hepatic vein, which opens into the inferior vena cava.

Composition of blood

Blood is a fluid connective tissue, which circulates throughout the body. It transports oxygen and nutrients to all parts of the body, down to the individual cells and brings back the waste products of metabolism from all over the body. It consists of a fluid portion, the **plasma** and the blood cells. **Erythrocytes** (red blood cells), **leucocytes** (white blood cells) and **thrombocytes** (platelets) are suspended in the plasma. Plasma minus **fibrinogen** (blood clotting protein), is called serum.

A normal human adult has 6-7 litres ±1 litre blood, of which 55% is plasma i.e. 3.70 litres ±0.55 litres and 45% are blood cells i.e. 2.55 litres ±0.45 litre.

Plasma

Plasma is a very complex fluid, which consists of about 90% water, and 7-8% proteins (albumins, globulins & fibrinogen). 2-3% of plasma contains glucose, amino acids, lipids, enzymes, hormones, antibodies and traces of many organic and inorganic materials including dissolved gases.

The normal average number /mm^3 of erythrocytes in persons living at high altitudes i.e. hilly areas is much higher than those living in plain. The average number of erythrocytes in these persons is nearly 7 million/mm^3. Do you know why this is so? The reason is that at high altitudes the oxygen is lower than the plains. So in order to meet out the oxygen requirements of the body the number of erythrocytes becomes high.

Blood Cells

The blood cells are of three types.

(i) Erythrocytes or Red Blood Cells **(RBCs)**

(ii) Leucocytes or White Blood Cells **(WBCs)**

(iii) Thrombocytes or Platelets

Erythrocytes or Red Blood Cells

In a normal human individual their number on the average is approximately 5 million / mm^3 of blood. In birds and mammals, the erythrocytes are produced in bone marrow. In mammals the mature erythrocytes lose their nucleus, mitochondria, Golgi bodies, and endoplasmic reticulum. They have biconcave disc-like shape. In all other vertebrates, the erythrocytes are nucleated and have an oval or ellipsoidal shape. The primary function of erythrocytes is to transport gases. The erythrocytes contain hemoglobin which is the respiratory pigment. It transports oxygen, from the lungs to other tissue of the body, and transports carbon dioxide from the tissues to lungs.

Practical Work: Study the blood smear under microscope.

1. Place a drop of anticoagulant like 1% sodium citrate solution on the slide and add a drop of fresh blood of chicken in the anticoagulant.
2. Spread the blood smear on the slide with the help of another slide edge.
3. Dry the spread for few minutes and observe under the microscope.
4. Draw the blood cells seen and compare it with the cells that you have studied.
5. Do not use blood or cheek smear from students , it may lead to serious consequences like contraction of aids and hepatitis.

Leucocytes or White Blood Cells

These cells are colourless and larger in size than the erythrocytes. They are nucleated and motile cells. These cells are of several types such as neutrophils,monocytes,lymphocytes,eosinophil and basopphils, which differ in structure and also in function. White blood cells defend the body from disease by engulfing and destroying germs and by producing antibodies. The total number of all these kinds of leucocytes is much less than the erythrocytes. In human beings their number ranges from 5000 to 7000 / mm^3 of blood.

Thrombocytes or Platelets

In mammals (including man), the blood in addition to erythrocytes and leucocytes contain platelets. The platelets are not complete cells (Fig. 12.13). They are minute and non-nucleated cell fragments. Their number in the circulating blood ranges between 150,000 to 350,000 / mm^3 of blood. They play an important role in blood clotting and are essential for it.

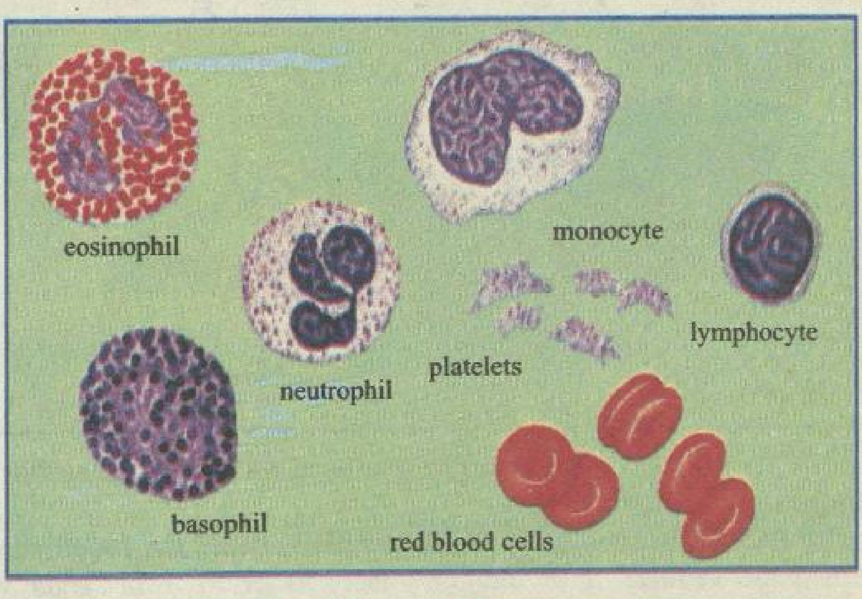


Fig 12.13 Blood cells

Blood pressure

Blood pressure is the pressure per unit area, which the flowing blood exerts on the walls of the blood vessels. In human beings, the blood pressure is measured at the artery of the upper arm. The measurement of blood pressure indicates the higher or systolic blood pressure and the lower or diastolic pressure. In normal young adults the systolic blood pressure is 120 mm Hg and the diastolic pressure is 80 mm Hg. Thus the normal blood pressure is expressed as 120/80 mm Hg.

12.7 Blood Vessels

In vertebrates there are three kinds of blood vessels, arteries, veins and capillaries. These vessels differ from each other in the structure of their walls, which is related to their functions.

Arteries

Arteries are the vessels which have to carry blood from the heart to all tissues of the body. The structure of the walls of the arteries is related to their function. They have the strongest and the thickest walls. The arterial walls are made up of three layers. The innermost layer, forming the lining of the inner surface of the arterial wall, is called **endothelium**. The middle layer consists of smooth muscles and **elastic tissue**. The outermost layer is also elastic and consists of **connective tissue**. Because of their elastic walls, the arteries are stretched when the blood enters them and then recoil slowly. Thus the blood in the arteries is 'pulsing' and the pressure in them fluctuates with the heart beat. You can feel the pulse if you place your fingers on an artery in the neck or the wrist. Because of their strong and elastic walls, the arteries are able to withstand the high pressure of blood in them.

The arteries, on reaching closer to the tissues, divide into arterioles. The arterioles, on entering the tissues, further divide into very fine branches, the capillaries.

Capillaries

The function of the capillaries is to deliver the blood as close to all the body cells as possible. The walls of capillaries are extremely thin, consisting of only a single layer of cells, the endothelium. The lumen of the capillaries is so narrow that the erythrocytes can move through them only in a single file. As the blood moves through the capillaries, the gases (oxygen and carbon dioxide), hormones, and other materials are exchanged with the surrounding tissues by diffusion.

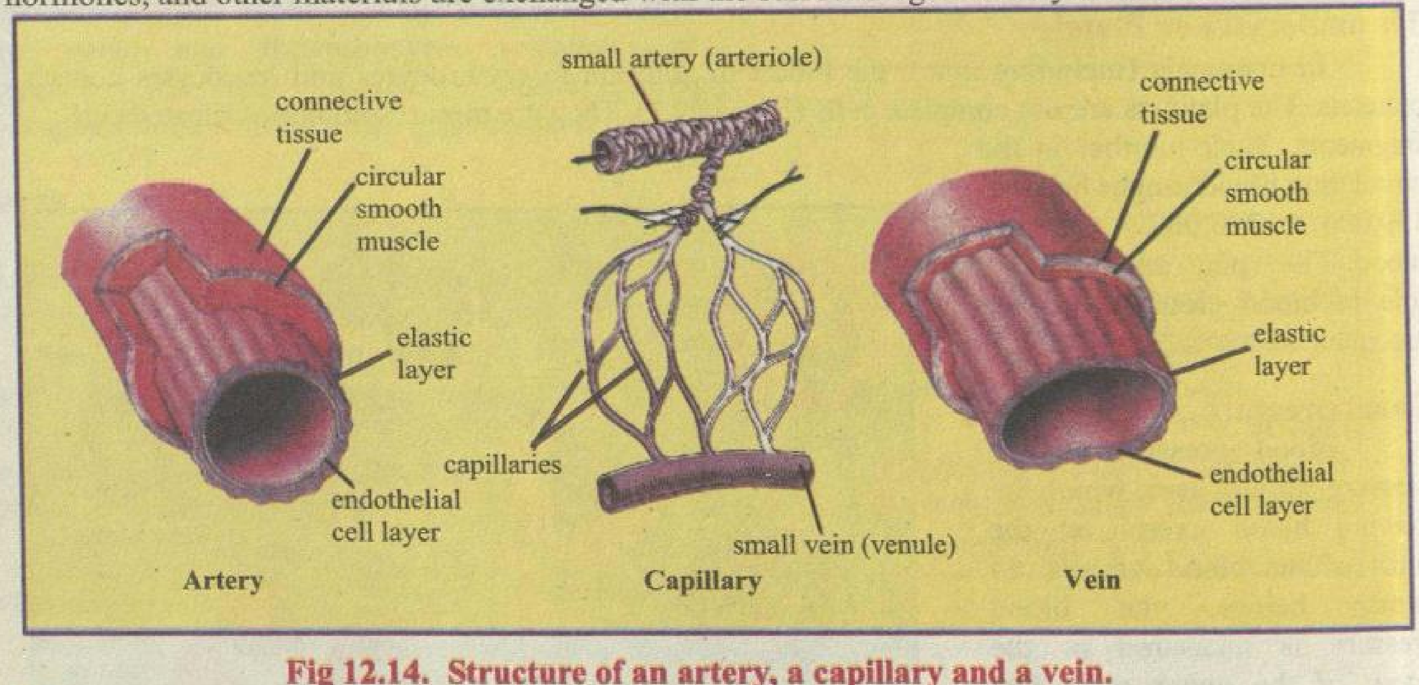


Fig 12.14. Structure of an artery, a capillary and a vein.

Veins

At the venous ends of the capillary beds, the blood flows back in slightly thicker vessels, called the **venules**. The venules join together to form larger vessels, the veins, which ultimately transport the blood from the tissues back to the heart. The walls of the veins, like those of the arteries, are also three-layered but they are less elastic and more pliable. The walls of the veins are thin and almost inelastic, that an empty vein collapses, whereas empty artery does not collapse (Fig. 12.14). Veins are provided with valves to check backward flow of blood.

Practical Work: Study the blood circulation in a fish tail or a frog's web or fish tail

1.Take the live specimen(frog or fish). If frog is selected pith it and then spread its web in the hind limb. Hold it in two slides and keep it at a place with a proper clip or thread. For fish keep wet cotton on gills for respiration and spread the tail as described in frog's web study.

2. Place it under the microscope and study the blood circulation.

3. How blood moves in capillaries? Draw a label.

Tissue Fluid

We have already learnt that capillaries reach closest to the tissues of the body and carry the blood to all tissues of the body. Here in the tissues, some fluid oozes out of the capillaries and fills the intercellular spaces. This colourless fluid thus accumulated in the intercellular spaces is called **tissue fluid**.

The escape of tissue fluid from the capillaries occurs through small gaps present in the walls of the capillaries. The number of gaps in the capillary walls varies greatly in different tissues of the body. These gaps are quite big so as to allow the passage of fairly large molecules but are not large enough to allow the escape of erythrocytes.

The tissue fluid is the medium through which the exchange of materials occurs, by diffusion, between the cells and the blood in the capillaries.

The tissue fluid also maintains a constant aquatic environment around the cells of the body.

12.8 Lymphatic System

Some tissue fluid present in the intercellular spaces enters the blind lymphatic capillaries (lacteals). After the tissue fluid has entered the lymphatic vessels, it is now called **lymph**.

The excess tissue fluid is returned to the blood through the **lymphatic system**. This system consists of an extensive network of thin-walled vessels, the **lymph capillaries**. The lymphatic system is quite distinct from the blood vascular system. The lymph capillaries have valves in their walls which allow the tissue fluid to enter the lymph capillaries but prevent its flow out of them. These capillaries join together to form larger vessels called the lymph vessels forming the lymphatic system. The lymphatic system serves as an accessory drainage system of the body by removing the excess fluid and dissolved substances that leak from the blood capillaries. The larger lymphatic vessels join the subclavian veins and pour their fluid into them. This is how the lymph is returned to the circulatory system. The lymphatic system transports fats from the intestine to blood stream. It also helps in defending against the attacks of bacteria and viruses by filtering or destroying them at special sites called **lymph nodes**.

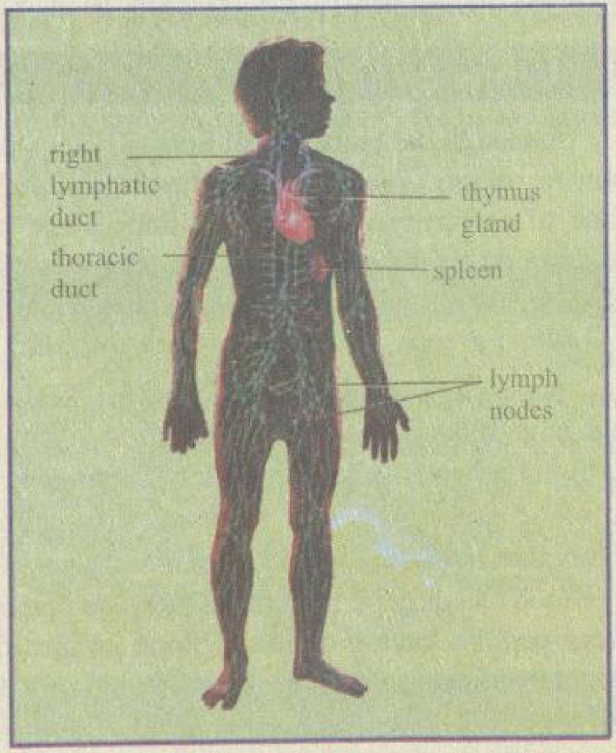


Fig 12.15 The human lymphatic system

NOT FOR SALE - PES

12.9 Heart Attack

The heart being a metabolically active organ constantly needs adequate energy and a good continuous supply of blood to carry out its activities. Heart attack can occur due to a a number of factors related with the blood circulation and interruption in oxygen supply to heart muscles.

The narrowing and thickening of arteries due to the deposition of cholesterol, fibrin, and cellular debris in the endothelial cells of the arterial wall, and also the accumulation of smooth muscles in the lining of the arteries, can also lead to a heart attack.

If an area of the heart musculature receives insufficient supply of blood, the oxygen supply to this area becomes deficient. Due to deficient supply of oxygen, the cardiac muscles, which are extremely sensitive, will die and this will result in a heart attack. Heart attack may also be caused by a narrowing or clot in coronary blood vessels.

Angina pectoris as a mild type of heart attack. It is also caused due to insufficient supply of blood to the cardiac muscles (not to the level that it would cause the death of the heart muscles) due to the narrowing of the coronary blood vessels. The symptoms of angina pectoris are the same as those of the heart attack i.e. chest pain (in the center of chest), and shooting pain in the left arm and the shoulder.

High level of cholesterol in the blood, high blood pressure, increased smoking, increased stress, and increasingly sedentary life style (lack of sufficient physical activity) can also cause heart attacks.

Recovery from a heart attack depends upon the extent of damage to the heart tissue. If the coronary blood vessels of the heart can enhance their capacity to provide sufficient supplies of blood to these tissue, this can bring about recovery from a heart attack.

The interference of blood supply to the brain, which may be due to a blood clot in the blood vessels (carotid vessels) or bursting of blood vessel in the brain, causes brain stroke. Stroke in smaller vessels results in paralysis while stroke in a large vessel may result in death.

12.10 Blood Group

Although the blood of all human beings apparently looks alike yet it differs chemically from person to person. The difference lies in the presence of different proteinaceous substances on the surface of erythrocytes. These substances are called **antigens**. These are the naturally occurring substances on the membranes of the erythrocytes. Particular **antibodies** are also found in the blood plasma. On the basis of the antigens and antibodies, the human blood be classified into A, B, AB and O blood groups. This is known as the ABO blood group system.

A person having antigen A on his RBCs would have B-antibody in plasma and so he/she would have blood group A. A person with antigen B on RBCs and A-antibody in plasma would have blood group B; a person with both antigens A & B on RBCs and no antibody in plasma would have blood group AB; and a person with neither A nor B antigens on RBCs and both A- and B-antobodies in plasma would have blood group O. (Table 12.1)

Blood can only be transfused between persons having the same blood groups. If it is transfused between persons having different blood groups, the antibodies present in recipient's plasma destroy the antigen-containing RBCs of the donor. It is called agglutination. Persons with blood group O are called universal donors as they don't have antigens A or B (also don't have antigen Rh). They can donate blood to persons with any blood group. The persons with blood group AB are called universal recipients because they don't have A- and B-antibodies.

Table 12.1 Human ABO Blood group System

Blood Group	Type of antigens on RBCs	Type of antibodies in plasma	Compatable	
			Can receive from	Can donate to
A	A	B	A,O	A , AB
B	B	A	B,O	B , AB
AB	A , B	None	A , B, AB, O	AB
O	None	A , B	O	A, B, AB, O

Table 12.2 Rh factor System

Rh Blood type	Type of antigens on RBCs	Type of antibodies in plasma	Compatable	
			Can receive from	Can donate to
Rh^+	Rh factor	None	Rh^+, Rh^-	Rh^+
Rh^-	None	Rh-antibody (on stimulation)	Rh^-	Rh^-, Rh^+

In addition to the classical ABO blood group system, there is another set of blood groups, the Rh system. The Rh system consists of Rh-positive (Rh) and Rh-negative (Rh) groups. These groups are identified on the basis of the presence of an antigen called **Rh factor**. If in a person Rh factor is present, he is Rh-positive and if not, he is Rh-negative. These two blood groups are also incompatible i.e. in blood transfusion an Rh-negative person should not be given Rh-positive. On the basis of the Rh factor, the blood groups A, B, AB and O would be A^- or A^+, B^- or B^+, AB^- or AB^+, O^- or O^+.

It is always advisable that before giving blood to a person, the blood group compatibility of the donor and the recipients must be checked. The donor and the recipient must have matching blood groups.

12.11 Haemophilia

Haemophilia is a hereditary disease in which the patient lacks some blood clotting factors. This disease is characterized by the failure of blood to coagulate. If the persons suffering from this disease have an injury from which blood flows, the blood will not coagulate or clot or will coagulate insufficiently to stop the flow of blood. This may result in excessive loss of blood which in some extreme cases, may prove to be fatal. In a normal human being if an injury occurs which bleed, the blood will soon coagulate and will form a clot at the point of rupture of the blood vessels blocking the blood flow.

12.12 Anaemia

Anaemia can be defined as the deficiency of red blood cells in the body. It normally occurs due to rapid loss of blood from the body or below normal production of red blood cells.

Symptoms of Anaemia

The usual symptoms of anaemia are yellowing of palate, weakness, dizziness, appearance of dark circles around the eyes, thinning of blood, loss of appetite etc.

Cause of Anaemia

Anaemia can be caused by a number of factors. The main causes of anaemia are:

(a) Iron is a major component of haemoglobin of red blood cells and an appropriate amount of iron should be available for synthesis of haemoglobin. The deficiency of iron would lead to less production of haemoglobin and consequently less production of red blood cells. As the number of red blood cells will fall down below normal level, the result would be anaemia. This is the major cause of anaemia worldwide.

(b) Nutritional Deficiency: Deficiency of some important nutrients like vitamin B 12 and folic acid also result in anemia.

KEY POINTS

1. Water is of extreme importance to living organisms. It plays an important role in the sustenance of life as major component of cell, as a solvent and as a metabolite.
2. Diffusion, active transport and osmosis are the processes involved in the transport of the material across the cells of living organisms as well as between the environmental and organisms.
3. Transpiration is a process of evaporation of water from the aerial parts (cells) of the plant, through structure, like stomata and cuticle. Temperature, wind, humidity, light and atmospheric pressure etc. are the factors which affect the rate of transpiration.
4. From the leaves, synthesized organic materials are transported to other parts of plant such as roots, stems and flowers.
5. Animals may have open and closed circulatory systems.
6. Blood circulatory system consists of blood, heart, arteries, veins and capillaries.
7. Fishes have single-circuit while all other vertebrates have double-circuit circulation.
8. Human heart consists of two atria and two ventricles.
9. Blood consists of plasma, red blood cells, white blood cells and platelets.
10. Human blood group are classified on the basis of A, B and Rh antigens.
11. In haemophilia, blood fails to clot while anemia is the deficiency of red blood cells.

QUESTIONS

1. Fill in the Blanks

(i) The principal physiological requirement of all organisms is the maintenance of ________.

(ii) The type of diffusion against the concentration gradient (up hill movement) involving the expenditure of energy is called ________.

(iii) The contents of the vacuole of plant cell is called ________.

(iv) The internal pressure exerted on the cell wall by the water moving into the cell is called ________.

(v) A concentration gradient is establishment between the root hairs and the soil water because of the ________.

(vi) Pull or suction force produced in the xylem vessels, because of the transpiration of water from the leaves is called ________.

(vii) The hypothesis proposed to explain the mechanisms of translocation of substances through sieve is the ________.

(viii) Whole blood minus blood cells is called ________.

(ix) Plasma minus fibrinogen is called ________.

(x) The pigment in blood for the transport of oxygen is ________.

(xi) The average number of leukocytes in man is ________.

(xii) The circulatory system in arthropods is ________ system.

(xiii) The artery which supplies blood to the heart muscles, is called ________.

(xiv) The atrio-ventricular apertures are guarded by ________.

(xv) In the normal young adults, the normal blood pressure is ________.

(xvi) The tissue fluid after it has entered the lymphatic vessels is called ________.

2.Write whether the statement is "true" or "false" and correct the statement if it is false.

(i) Temperature is an important factor in controlling the rate of transpiration as it influences the opening and closing of stomata.

(ii) Substances, when dissolved in water, becomes chemically inert.

(iii) Atmospheric pressure plays an important role in the life of plants as it provides the forces or tension to pull water and minerals ions up the xylem vessels.

(iv) When guard cells are flaccid, then inner margins curve apart from each other opening the aperture guarded by them.

(v) The transport of synthesized or stored food, from the leaves or the other storage organs to all other parts of the plant is called translocation.

(vi) Lymph flows from bigger lymph vessels to the smaller lymph capillaries

(vii) The inter atrial and inter ventricular septa prevent the mixing of deoxygenated and oxygenated blood, in human heart.

(viii) In a human the normal blood pressure is expressed as 180/120 mm Hg.

(ix) Due to over supply of oxygen, the cardiac muscles, which are extremely sensitive, will die resulting in heart attack.

(x) The persons with blood group O are considered to be universal recipients as they have both antigen A and B.

3. Each question is followed by four options. Encircle the correct answer.

(i) The complexity of transport system is related to:

- **(a)** size and the metabolic rate of an organism
- **(b)** the type of food taken by an organism
- **(c)** to the habitat of the organism
- **(d)** all of the above

(ii) The transport system facilitates:

- **(a)** the elimination of metabolic wastes of each cell
- **(b)** to adjust in the habitat
- **(c)** movement of materials
- **(d)** all of the above

(iii) The diffusion of molecules of some substances with the help of carrier Proteins is called:

- **(a)** active transport
- **(b)** osmosis

(c) facilitated diffusion
(d) cyclosis

(iv) Chemically the carrier substances in facilitated diffusion are:
(a) proteins (b) lipids
(c) carbohydrates
(d)nucleic acids

(v) The movement of water into the plant cell produces ______________ in the cell.
(a) turgor (b) flacid state
(c) none of the a and b
(d) both a and b

(vi) The internal pressure exerted on the cell wall by the water moving into the cell is called
(a) root pressure (b) water potential
(c) turgor pressure
(d) osmotic pressure

(vii) The loss of water from cells of the leaves makes their cells:
(a) turgid (b) flacid
(c) none of the a and b
(d) shrinked

(viii) Because of transpiration pull and cohesion or adhesion of water molecules, the water moves in the xylem vessels as
(a) packages of water
(b) an unbroken column
(c) none of the two
(d) broken column

(ix) Whole blood minus blood cells is called:
(a) tissue fluid (b) lymph
(c) plasma (d) serum

(x) If fibrinogen is removed from the blood plasma, the fluid left is
(a) interstitial fluid (b) lymph
(c) serum (d) tissue fluid

(xi) The average number of leukocytes in human beings is
(a) 15000 to 18000/mm^3
(b) 2000 to 3000/mm^3
(c) 7000 to 8000/mm^3
(d) 1500 to 1800/ mm^3

(xii) The function of platelets is
(a) to produce antibodies
(b) to phagocytose the bacteria
(c) to form platelet plug or clot
(d) to carry gases

(xiii) In single circuit circulatory system, the blood from the heart goes to
(a) all tissue of the body
(b) the gills
(c) the skin
(d) the lungs

(xiv) The single circuit heart is found in
(a) amphibians
(b) reptiles
(c) fishes
(d) mammals

(xv) The right atrio-ventricular aperture is guarded by
(a) bicuspid value
(b) semilunar valves
(c) tricuspid value
(d) no values

(xvi) What is true about lymph capillaries?
(a) these are blind ended tubes
(b) these are open tubes
(c) these are formed by division in arteries
(d) these join and form veins

4. Write short answers of the following questions.

(i) What is a clot? What is the function of clot ?

(ii) Name the three general types of cells in blood.

(iii) What are the two major functions of leucocytes?

(iv) What important role is played by transpiration in plants?

(v) Define turgor in plant.

(vi) Define mass flow hypothesis.

(vii) Differentiate between open and closed circulatory system.

(viii) How haemophelia is different from anaemia ?

5. What are blood groups?
List the four ABO blood types. Why is type O blood considered a universal donor?

6. What is meant by term Rh positive? How does Rh incompatability effect blood transfusion?

7. Describe the major functions performed by blood.

8. Discuss the role of transpiration in plants.

9. How food is transported in plants?

10. Write notes on the followings:

(i) Blood pressure

(ii) Lymphatic system

(iii) Heart attack

(iv) Anaemia

(v) Role of water in life

EXCRETION

In this chapter you will learn:

- Definition and need of excretion.
- Waste products in plants.
- Methods of excretion, adopted by plants.
- Types of waste products in animals.
- Excretory organs found in certain animals.
- Excretory system in man, including the structure and function of kidney.
- Brief description of osmoregulatory function of kidney.
- Brief introduction of kidney stone, kidney failure, diagnosis and its treatment.

13.1 Introduction

All organisms carry out hundreds of reactions in their bodies which altogether are known as metabolism. The metabolism can be generally divided into two types: the catabolism and the anabolism. The catabolism is the breaking down of complex organic molecules into simpler compounds in order to obtain energy which is utilized for the performance of various activities of life. In catabolic reaction carbohydrates, proteins and lipids are broken down or (oxidized) through enzymatic reactions step by step to generate chemical energy in the form of ATP molecules.

$$\text{Carbohydrates} + \text{Oxygen} \longrightarrow CO_2 + H_2O + \text{energy}$$

$$\text{Proteins} + \text{Oxygen} \longrightarrow CO_2 + H_2O + NH_3 + \text{energy}$$

$$\text{Lipids} + \text{Oxygen} \longrightarrow CO_2 + H_2O + \text{energy}$$

By looking at the above reactions you can know that carbon dioxide, water and ammonia are formed in these reactions. They are regarded as waste and surplus products because they are not utilized in the body of organisms (with the exception of plants which can use CO_2 for photosynthesis). These waste products must be removed from the body as soon as possible because these are toxic (poisonous) for the cells if they accumulate in the bodies of the organisms. The CO_2, if not removed quickly can lead to lowering of pH which can be dangerous for life.

Ammonia is even more toxic than CO_2, it should be quickly removed from the body or converted into less toxic material but even then the less toxic materials like urea, uric acid have to be eliminated from the bodies of organisms.

The concentration of water in the tissue fluid of mammals is maintained within the range 97-99% or a mean of 98%. Similarly the amount of water in the blood is regulated at about 92%. If the water exceeds this level then it collects in the tissues causing **dropsy**. If the concentration of H_2O falls below the normal line, it can cause dehydration of body. These waste products which are actually metabolic by-products have therefore to be eliminated from the bodies of living organisms. The process of removing the waste products from the body is known as **excretion**.

13.2 Excretion in Plants

The living organisms differ in their methods of excretion. Generally there are no specialized organs or systems in plants for excretion. The unwanted metabolites may be secreted into intra or inter-cellular spaces. The aerating system of plants makes possible the ready diffusion of respiratory CO_2 into the surrounding water or atmosphere. In some plants the waste metabolites may be deposited in leaves, seeds and fruits which when shed can easily carry with them these accumulated un-necessary substances. It can be noted that such elimination is purely secondary to the true purposes of leaf fall or seed and fruit dispersal.

13.2.1 Removal of Carbon dioxide and Oxygen

CO_2 is produced as a result of **respiration**. As the process of respiration takes place continuously in all living cells, CO_2 is produced continuously and discharged through the **stomata**, or **lenticels**. On contrary, oxygen (O_2) is released only during the day-time, because it is a by-product of the process of **photosynthesis.** The CO_2 thus produced during daytime is consumed by the mesophyll cells, in photosynthesis. Only a small quantity of oxygen produced during photosynthesis is used for respiration. The excess oxygen is released from the leaves through stomata.

Green plants give off oxygen as waste in the day time and CO_2 at night.

At night the photosynthesis stops, the atmospheric O_2 is used for respiration in plants and CO_2 is evolved as a by-product.

13.2.2 Excretion of Extra Water

Water is one of the major basic needs of the plants The water in plants is used for photosynthesis, for transpiration and carry out many other functions like transportation of different materials etc. The plants obtain water largely from soil. Whereas a small percentage of it is provided as a result of respiration. The excess water is removed in the form of water vapours by the process of **transpiration**. Sometimes, the removal of this excess water takes place by **guttaion**. For example in cabbage, potato and strawberry etc., the droplets of excess water (similar to the dew drops) often appear at the tips and margins of leaves which enlarge and drop-off later on. In this way such plants and few grasses get rid of the extra water (Fig. 13.1).

Transpiratin: It is the process by which the water gets evaporated from the plant cells, through stomata etc.

Fig. 13.1 The phenomenon of Guttation in Strawberry leaves

13.2.3 Latex, Resins and Gums

In some plants the products like latex, resins and gum are secreted in special canals or ducts, present in the plant body. Such products are not ordinarily excreted from the plant, but they trickle out (leak slowly) of the plant when some part of it is damaged. (Due to this unique behaviour, some scientists are also reluctant to regard them as waste products of plants.) The common examples of **latex** producing plants are Rubber plant and the Pines. **Resins** and **gums** are secreted by *Acacia arabica* (keekar) etc and **mucilage** is secreted by *Hibiscus* (ladyfinger).

13.3 Excretion in Animals

The principal metabolic waste products in most animals are water, carbon dioxide, and nitrogenous wastes. Carbon dioxide and some water are eliminated from the bodies mainly by respiratory structures, whereas most of the water and nitrogenous wastes are excreted by special excretory organs.

Nitrogeneous wastes includes ammonia, uric acid and urea. Recall that amino acids and nucleic acids contain nitrogen. During the breakdown of amino acids, the nitrogen-containing amino group is removed by a process called deamination and converted to ammonia. However, ammonia is highly toxic. Some aquatic simple animals excrete it in dissolved form into the surrounding water through the process of diffusion before it can build up to toxic levels in their tissues. But in complex terrestrial organisms, including humans, ammonia being very toxic, is converted to some less toxic nitrogeneous wastes such as urea or uric acid.

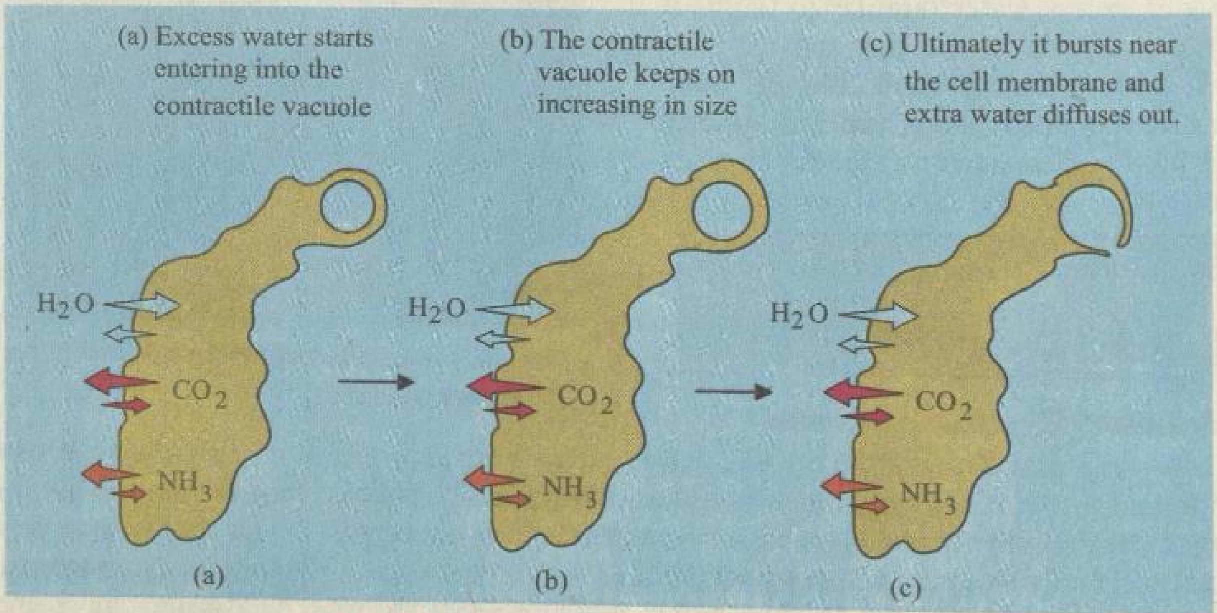
Uric acid is produced both from ammonia and by the breakdown of nucleotides from nucleic acids. Uric acid is the least toxic and can be excreted in a crystalline form with a little use of water. This is an important adaptation for conserving water in many terrestrial animals such as insects, reptiles and birds.

In birds, the frequent excretion of uric acid in the faeces and the absence of urinary bladder keeps the body weight light which is very important for flight.

Urea is the principal nitrogenous waste product of amphibians and mammals. It is produced mainly in the liver. Urea is far less toxic than ammonia and so can accumulate to some extant in the body without causing tissue damage. Because urea is highly soluble, it is excreted dissolved in water. For its excretion, urea needs less water than ammonia but needs more water than uric acid.

13.3.1 Excretion in *Amoeba*

In *Amoeba* and other unicellular freshwater animals contractile vacuoles are present. These contractile vacuoles are osmoregulatory in function as they are involved in the removal of excess water from the body. This water however also carries with it some of the ammonia and CO_2 which are produced in metabolism. However, most of the ammonia and CO_2 diffuse out of the body through cell membrane in the dissolved form (Fig 13.2).


(a) Excess water starts entering into the contractile vacuole

(b) The contractile vacuole keeps on increasing in size

(c) Ultimately it bursts near the cell membrane and extra water diffuses out.

Fig. 13.2 Excretion in *Amoeba*.

13.3.2 Excretion in Planaria

In planaria a clearly defined excretory system exists. It consists of two or more highly branched longitudinal tubules. Some side branches of the tubules end in bulb-like cells into which long flagella project. These flagella, beating constantly assume the appearance of a flame and give the system its name – flame cell system. These flagella create continuous currents within the flame cell system and the currents carry fluid and waste materials out of the body through the excretory pores present on the general body surface (Fig 13.3). In planaria, ammonia and extra water are eliminated through this system. CO_2 is removed through the general body surface by diffusion.

A tuft of flagella present in the flame cell moves in a way similar to that of a flickering candle's flame, thus given the name "**Flame**

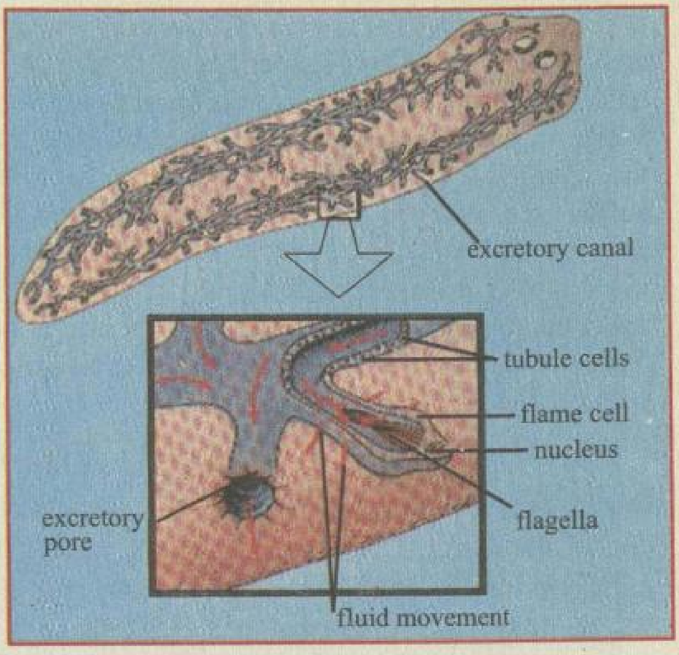


Fig. 13.3 Excretory system of a Planarian

13.3.2 Excretion in Earthworm

In the earthworm the excretory system is more advanced and complex than that of planaria. Excretion is carried out by nephredia which are closely associated with its closed circulatory system. Each segment of the earthworm's body contains a pair or in some species a cluster of **nephredia**. The body fluids from the body cavity enter a nephridium through the membrane of a bulb-like nephrostome, which is the ciliated opening into the nephridium.

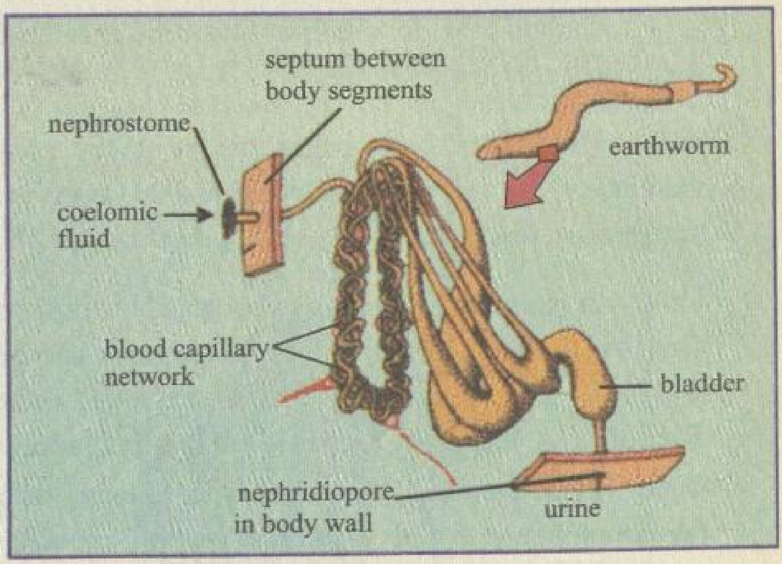


Fig 13.4 Nephridium of earthworm

The nephridium then continues into a coiled tubule which is closely associated with blood capillaries. This allows a selective reabsorption of materials. The nephridium ends into a large bladder, which opens to the exterior by means of a nephridiopore. (Fig. 13.4). Water, urea and CO_2 are the waste products in earthworm. Most of the CO_2 diffuses out in dissolved state through general body surface.

13.3.4 Excretion in Cockroach

The nitrogenous wastes, inorganic salts and CO_2 are the major excretory products in insects like cockroach, grasshopper etc. These unwanted and poisonous substances are removed through different organs e.g. **Malpighian tubules** and **tracheal tubules**. The CO_2 is eliminated from the body by means of tracheal system. Water, salts and nitrogenous wastes, chiefly in the form of salts of uric acid, are extracted by Malpighian tubules from the haemolymph and pass them in the lumen of the tubules. From here the extracted materials move in the solution form called urine towards the ileum. Water and certain inorganic salts are absorbed from the urine into the proximal part of the tubules. This action of reabsorption leads to the precipitation of the uric acid in the lumen of the tubules. As the urine moves on to the hinder part of the digestive tract, more water is absorbed from the precipitated mass so that solid uric acid is finally thrown out with the faeces.

The ability to conserve water in the excretory process in insects is highly adaptive and is one of the reasons for these insects for successfully invading dryland.

Malpighian tubules are very fine yellowish thread-like processes which open into the anterior end of the ileum. They are arranged in six groups each having about fifteen blind ended tubules which float freely in the haemolymph. Some uric acid is stored in special cells of the fat body and remain their throughout the life of the cockroach. This is excretion by storage.

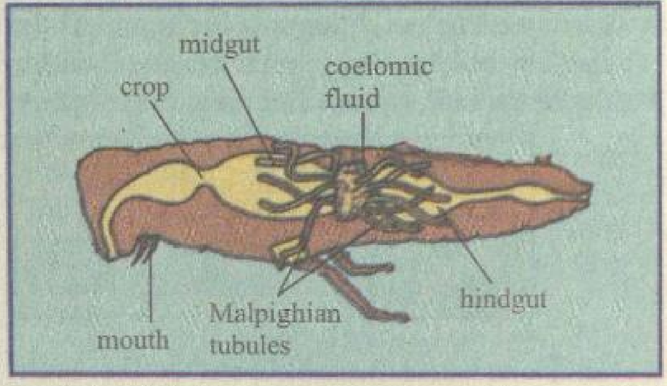


Fig 13.5 Excretory system in Cockroach

13.4 Excretion in Vertebrates

Carbon dioxide, mineral salts, urea, creatinin, uric acid, bile pigments and excess water are the waste products in vertebrates.

The kidney is an organ unique to the vertebrates. It is the chief excretory unit in higher vertebrates but its major function in the lower vertebrates (fish) is osmoregulation. In fishes the nitrogenous waste are mainly eliminated through the gills.

In mammals, skin has sweat glands which produce sweat for cooling the body in hot weather. This sweat has some quantities of certain waste products like urea, salts, etc. So skin also acts for excretion to some extent. The lungs as you know are involved in elimination of CO_2 and water. Some excretion also takes place through intestine as in the amphibians. Main excretory role in reptiles, birds and mammals is however played by a pair of kidneys and their ducts.

In some marine reptiles, external devices have evolved to deal with the excretion of excess salts. These salts excreting glands, are similar to those of birds.

13.4.1 Human Urinary System

The human urinary system consists of a pair of kidneys with attached ureters. The **ureters** from both sides open into the bladder which opens into the **urethra**. Each kidney is a bean shaped organ enclosed in a fatty membrane. They are found attached to the dorsal body wall within the abdominal cavity, one on each side of the vertebral column, just above the waist-line. The right kidney lies slightly anterior to the left (Fig. 13.5). The concave side of the kidney faces the vertebral column. The depression in the center of this surface is called **hilus**. It provides a place for the renal artery, renal vein and nerves to enter and leave the kidney.

The longitudinal section of a human kidney shows that it mainly consists of two regions. The outer dark red region is called **cortex**. The inner pale-red region is called **medulla**. The medulla consists of several cone shaped areas called **pyramids**.

The pyramids project into a funnel-like space present in center of concave surface of kidney called **renal pelvis**.

A tube, called **ureter**, originates from the renal pelvis (of each kidney). The ureters from both the kidneys open in a bladder, called as **urinary bladder**.

The urinary bladder opens to outside through a duct known as **urethra**.

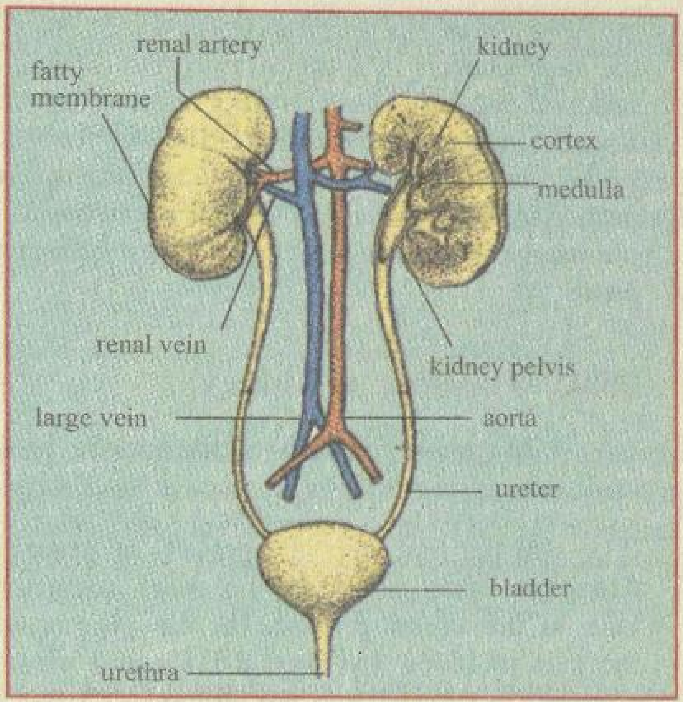

renal artery
kidney
fatty membrane
cortex
medulla
renal vein
kidney pelvis
large vein
aorta
ureter
bladder
urethra

Fig. 13.5 Human urinary system

Each kidney is composed of large number of tiny tubes – the urinary tubules or **nephrons**. Each nephron further consists of a cluster of blood capillaries called **glomerulus** and a long tubule called **renal tubule**. The renal tubule is closed at one end, which enlarges into a cup-shaped structure called **Bowman's capsule**. The Bowman's capsule is surrounding the glomerulus and both are collectively called **renal corpuscle**. Fig 13.6 & 13.7.

The renal tubule of nephron is much longer and it originates from the Bowman's capsule and its wall is single cell in thickness. It is surrounded by a network of capillaries. Its first portion

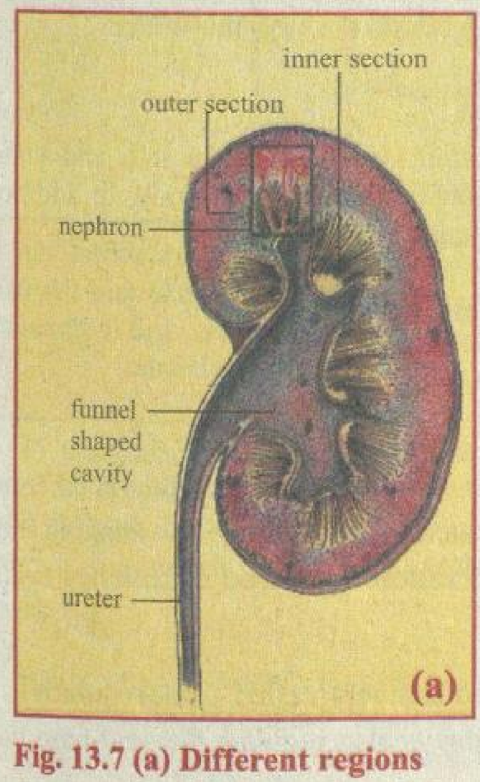

inner section
outer section
nephron
funnel shaped cavity
ureter
(a)

Fig. 13.7 (a) Different regions within human kidney

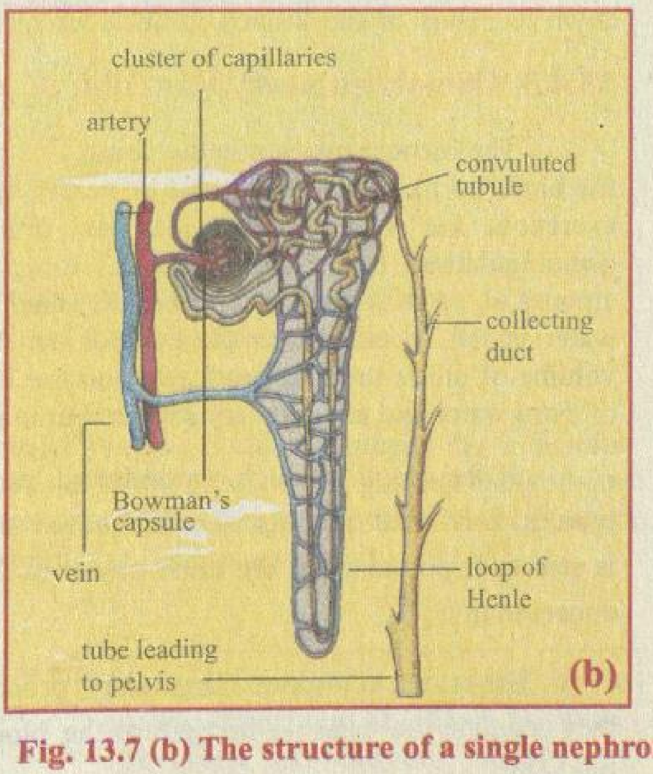

cluster of capillaries
artery
convuluted tubule
collecting duct
Bowman's capsule
vein
loop of Henle
tube leading to pelvis
(b)

Fig. 13.7 (b) The structure of a single nephron

is twisted upon itself in a very complex way and the next portion is quite straight but U-shaped called **Loop of Henle** - the name after the scientist who discovered it. The last portion of the tubule is again convoluted and like the last portions of several other nephrons, it ultimately opens into larger duct called **collecting duct**.

Practical Work: Examination of a longitudinal section of a mammalian kidney or model of kidney:

(i) Teacher will make a sheep's / goat's kidney available in laboratory / classroom.

(ii) Cut it longitudinally into two equal halves. Keenly observe with the help of hand lense and draw the cut surface.

(iii) Use the similar colours (to the original) in order to differentiate between cortex, medulla, pyramids and renal pelvis.

(iv) Label the diagram.

(v) Describe briefly the function of ureter and urinary bladder.

13.4.2 Function of Kidney:

The main function of the kidney is the urine formation which takes place in three steps:

In the first step, the process of **pressure filtration** takes place in the renal corpuscle. Due to the blood pressure in the glomerulus, the part of blood (without R.B.Cs and plasma proteins) is filtered into the Bowman's capsule and is called **Bowman's filtrate**. It mainly consists of **salts**, **glucose**, **urea** and **uric acid** dissolved in water. From glomerulus it trickles down in the **renal tubule**.

In the second step, the process of **selective reabsorption** takes place by the network of blood capillaries which surrounds the tubule. Firstly, all the glucose with much of water is reabsorbed Then some of the salts are sent back into the blood. In the third step the unnecessary salts together with urea and uric acid (nitrogenous waste products) with excess water (now called **urine**) travel down to pelvis of the kidney, from where it moves to bladder through the ureter.

13.4.3 Osmoregulatory Function of Kidney

The osmoregulation is the control of water and other ingredients (like salts and acids etc.) in the blood to maintain a constant or nearly constant water potential in the body. In addition to the excretion, the kidneys also play an important function of osmoregulation. If the blood contains too much water, a small amount of water is reabsorbed from the renal tubules, while more water is left to enter into the bladder. In this manner a large volume of dilute urine is produced, and the human body gets rid of extra water and unnecessary salts and uric acid.

Besides excretion the kidneys help to maintain the pH, blood pressure and composition of blood plasma.

If the blood is much concentrated, more water is absorbed back into the blood from kidney tubules, and small quantity of concentrated urine is produced. The message for drinking more water is sent to hypothalamus, the thirst center in the brain, to restore the blood consistency to its normal concentration.

The above mentioned regulatory processes are collectively called **osmoregulation,** because they regulate the osmotic strength of the blood. The kidneys also regulate the acid-base balance of the body.

13.5 Kidney Failure:

If one kidney of a person is damaged or its nephrons fail to function he can still lead normal life with one fully functional kidney. The question is: What happens if both the kidneys fail to work? The answer is very simple that the person will die, if the proper medical treatment is not given. For this purpose the patient can be treated with a **Kidney machine (dialyser)** and or by a **Kidney transplant**.

13.5.1 Kidney Machines (Dialyser)

There are two methods of dialysis, i.e mechanical removal of nitrogenous waste from kidneys.

1. Arterial blood dialysis (haemodialysis)

In haemodialysis an artificial kidney machine called dialyser is used. This machine consists of a tank of sterile dialysis fluid surrounding a long dialysis tubing. Arterial blood from the person with kidney failure is pumped slowly through the dialysis tank via dialysis tubing. The tank contains a dialysis membrane between the blood and the dialysis fluid. Urea and other wastes diffuse from the blood through the dialysis membrane into the dialysis fluid. Blood is withdrawn and send back to the patient by a shunt installed in a fore arm's vein (Fig. 13.8).

Kidney machine is used by the patient twice or thrice a week. This process of removing the wastes from blood takes about four to five hours.

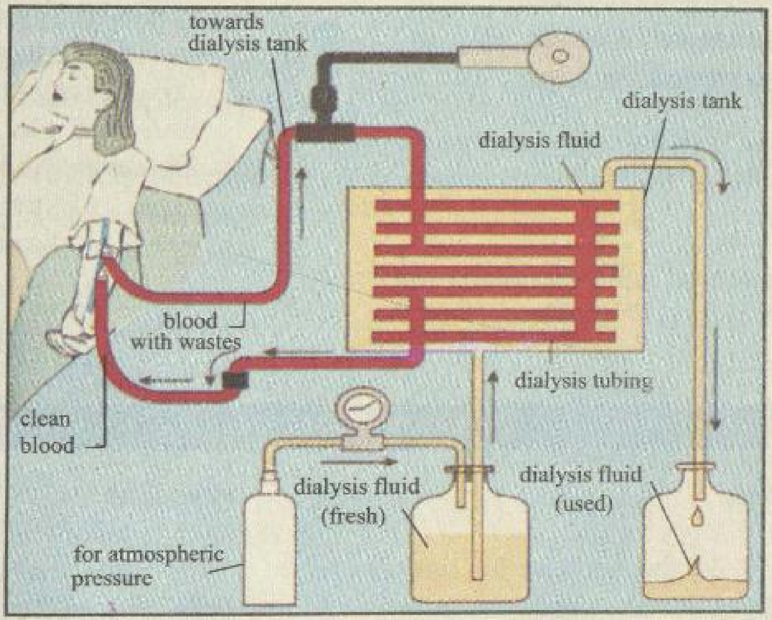


Fig. 13.8 The process of arterial blood dialysis (haemodialysis)

2. Body cavity (peritonial) dialysis

In peritonial or body cavity dialysis the sterile dialysis fluid is pumped by a portable machine into the abdominal peritonial cavity which is the space between the gut and the abdomen. Here the gut capillary walls act as dialysis membranes. Urea and other waste materials diffuse into the dialyisis fluid which is drawn by another pump leading the fluid to waste.

13.5.2 Kidney Transplant

As the process of dialysis needs to be repeated after every few days and is rather unpleasant, therefore the patient can also be given an alternative treatment that is kidney transplant. In this type of treatment the kidney of a healthy person is transplanted to the patient. The new

In order to get best results in the kidney transplant, the tissue and body chemistry of both the 'donor' and 'patient' must be much similar.

kidney is connected to the patient's blood and urinary system. The kidney may be donated by one of the closest relatives. The tissue and body chemistry of the donor should be similar to that of the patient. When the donor is unrelated or belongs to some other blood group the problems like tissue rejection may occur and the patient's body destroys the donated kidney.

Some other kidney disorders produced as a result of kidney stones or an accidental injury to the kidney may lead to the serious fall in blood pressure.

> The kidney stones can be diagnosed by X-rays and sonography by ultrasound machine. The renal surgery for removal of stones is now being replaced in some cases with the lithotripsy (breaking of stone with ultrasound waves).

KEY POINTS

1. 'Excretion' is the process by which the waste products and excess water is removed from the bodies of both plants and animals.
2. The waste produced in plants are, CO_2, H_2O, O_2 and latex etc. whereas that in animals are ammonia, urea, uric acid, extra salts and extra water etc. in addition to water$_2$ and CO
3. The urinary system of mammals mainly consists of two kidneys, ureters and a bladder.
4. The basic structural and functional unit of a human's kidney is 'Nephron.'
5. Besides excretion, the kidney also plays an important role in osmoregulation.
6. "Dialysis" and "kidney transplants" are the two main types of kidney treatment.
7. "Dialysis" is time consuming treatment while 'Kidney Transplant' may fall "tissue rejection", if the new kidney is unrelated to that of the patient. However, both (above mentioned) types of treatment are successfully being used under medical supervision.
8. The kidney disorder like "kidney stone" is also being treated with the "Lithotripsy", these days.

QUESTIONS

1. Fill in the blanks.

(i) ________ is the process by which metabolic waste products and harmful materials are removed from the bodies of living organisms.

(ii) ________ + catabolism ⟶ metabolism.

(iii) In plants the excess oxygen is removed through ________ which lie in the lower epidermis of the leaves.

(iv) The removal of the waste products from *Amoeba* takes place through the specialized organelles, called ________.

(v) The main excretory organs in planaria are ________ and attached ducts.

(vi) The excretory products produced in earthworm are ________ and ________ in addition to excess water.

(vii) The excretion in cockroach takes place through ________.

(viii) The major function of kidney in lower vertebrates (fish) is ________.

(ix) The Bowman's capsule surrounds the cluster of capillaries called ________.

2. Write whether the statement is true or false and write the correct statement if it is false.

(i) The green plants give off "oxygen" as waste product, during photosynthesis.

(ii) Respiration is the process by which water evaporates from the aerial parts of a plant.

(iii) 'Latex' is produced by pines, whereas 'Resins' are the products of 'rubber' plants.

(iv) In man, the 'left kidney' lies slightly higher than the right kidney.

(v) Each kidney is composed of a large no. of tiny tubules called, nephridia.

3. Each question is followed by four options. Encircle the correct answer.

(i) The type of activity in which the smaller substances combine to build up the more complex ones is called;

(a) Respiration (b) Reproduction
(c) Metabolism (d) Anabolism.

(ii) The excess water in plants is removed by the process of
(a) Respiration(b) Transpiration
(c) Guttation (d) Both b and c

(iii) In *Amoeba* ammonia diffuses out through;
(a) Mitochondria
(b) Golgi complex
(c) Nucleus
(d) Cell membrane

(iv) In earthworm the no. of nephridia in each segment is about;
(a) Four (b) Five
(c) Nine (c) Two

(v) The part of nephridium which opens into the body cavity by a ciliated funnel is called;
(a) Nephridiopore
(b) Bowman's Capsule
(c) Nephrostome
(d) Mouth

(vi) The name of the common mineral salt present in sweat is;
(a) Calcium Oxalate
(b) Sodium Chloride
(c) Potassium Sulphate
(d) Iron Sulphide

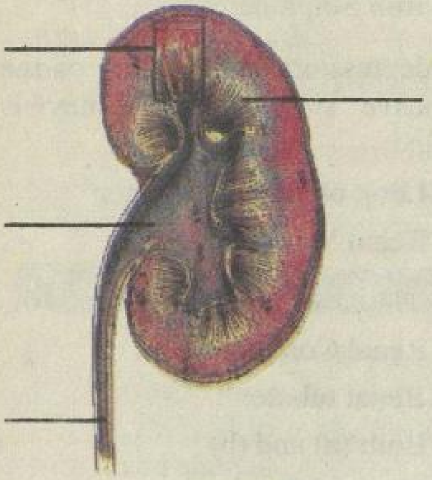
(vii) The depression in the centre of the concave side of the kidney is called;
(a) Loop of Henle(b) Ureter
(c) Renal Vein (d) Hilus

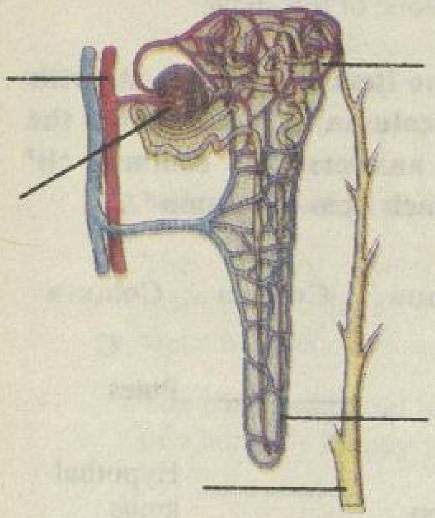
(viii) The 'Nephron' mainly consists of;
(a) Renal Corpusle
(b) Renal tubule
(c) Both (a) and (b)
(d) None of the above

4. Match the items of column 'A' with that of column 'C' and write the correct answers in column 'B' against each item of column 'A'.

	Column A	Column B	Column C
(i)	Latex	________	Pines
(ii)	Tissue rejection	________	Hypothalamus
(iii)	Resins	________	Rubber
(iv)	Thirst centre	________	Planarian
(v)	*Amoeba*	________	Human kidney
(vi)	Earthworm	________	Kidney transplant
(vii)	Flame cells	________	Nephridia
(viii)	Cortex and medulla	________	Contractile vacuole
		________	Malpighian tubules

5. Identify the following diagrams and label their parts.





6. Write short answers to the following questions:

(i) What is meant by "Excretion?"

(ii) Briefly describe; Why excretion is necessary?

(iii) Differentiate between 'Catabolism' and 'Anabolism'.

(iv) What is the difference between "Transpiration" and "Guttation."

(v) Name some waste products produced in plants.

7. Summarize some methods of excretion adopted by plants.

8. What is the main function of kiendy? Describe in terms of ultrafiltration, reabsorption and urine formation.

9. Explain the structure of 'Nephron' with the help of a labelled diagram.

10. Write short notes on;

(a) Dialysis (Kidney machine)

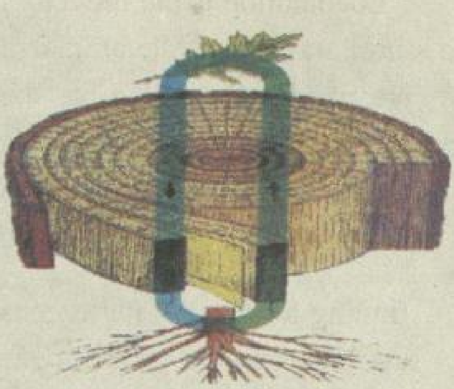
(b) Kidney Transplant.

14

SUPPORT AND MOVEMENT

In this chapter you will learn:

- Importance of support, movement and locomotion.
- Identification, description and microscopic examination of supporting tissues of young and woody Dicotyledonous stem.
- Definition of tactic, nastic, tropic movements; three types of tropism (geotropism, phototropism and hydrotropism) in plants.
- Importance of tropic response and explanation of geotropism in root and phototropism in shoot in terms of auxins.
- Locomotion in plants (*Euglena* and *Volvox*) and in animals (*Amoeba* and *Paramecium*).
- Two types of skeleton (axial and appendicular) and their function in support and movement.
- Role of muscles in the support of skeleton; their movements (action of flexors and extensors) and functions of tendons and ligaments in relation to movements.
- Defects of skeletal system; Joints (ball and socket and hinge) their function and dislocation



14.1 Support, Movement and Locomotion

Support

The need for support became greater as animals and plants increased in size through the process of evolution. This was particularly true for organisms which left the water and colonised land. Support in different organisms may be provided by:

- skeleton as in man and other animals.
- mechanical tissues in woody parts of plants.
- turgidity of parenchymatous tissues in non-woody parts of plant which remain firm and erect because of the pressure within these cells.

During period of water shortage, the tissues of such plants lose water and it results in wilting. Similarly bodies of animals would collapse and fail to maintain shape and posture, if they are not supported properly.

Movement

Movement is a response shown by a living organism towards or away from the stimulus. It is more clearly visible in most of the animals than in plants. It can occur at:

- **Cellular level** e. g., cytoplasmic streaming and motility of gametes.
- **Organ level**, e. g., heart beat, movement of a limb, shoot, root etc.

Stimulus (plural: stimuli) is any influence or change in external and internal environment. **Response** is a change in the activity or reaction of the organism to the stimulus.

Locomotion

Locomotion is the movement of whole organism from one place to another under the influence of a stimulus. Most of the animals have the power of locomotion except a few e.g. corals and sponges. They are fixed to one place but they can move parts of their bodies. Some microscopic water protists e.g. *Euglena, Chlamydomonas* are able to move freely from one place to another, they resemble animals in this respect.

Locomotion is used for:

1. finding food by living organisms.
2. avoiding capture by the enemies.
3. dispersal of seeds and fruits
4. finding new and favourable environment.
5. bringing together individuals for reproduction.

14.2 Support in Plants

Most plants are stationary. They are not able to move like animals from one place to another. They usually prepare their food themselves during the process of photosynthesis but to fix in one place or position and to keep their whole bodies firm and erect plants should have some supporting tissues and materials. These are present in almost all parts of the body e. g. root, stem, branches, leaves etc. In stem they are in abundance. These supporting tissues keep the stem firm and other parts specially leaves in such a position to get the maximum light for carrying on photosynthesis besides performing other processes.

14.2.1 Supporting tissues of young dicotyledonous stem

Young dicotyledonous stem depends for its rigidity or support on the:

- osmotic pressure and turgidity of parenchymatous tissues,
- the cylinderical distribution of its vascular bundles,
- thick walled collenchymatous (living) and sclerenchymatous (dead) tissues.

In young dicot stem of sunflower (Fig. 14.1), support is due to the cylindrical arrangement of vascular bundles near the outside of stem. Pith is present in the center while cortex is present outside the cylindrical structure. The turgidity and the osmotic properties of the parenchymatous tissues of cortex and those of pith keep the stem stiff and firm. The **parenchyma** (i) becomes tightly packed and appear to serve as packing material; **collenchyma** (ii) in the stem of broad bean provides a flexible support and **sclerenchyma** (iii) thick walled, dead tissues & elongated fibres (iv) often organized in bundles, provide a relatively rigid support to the stem (Fig. 14.2.).

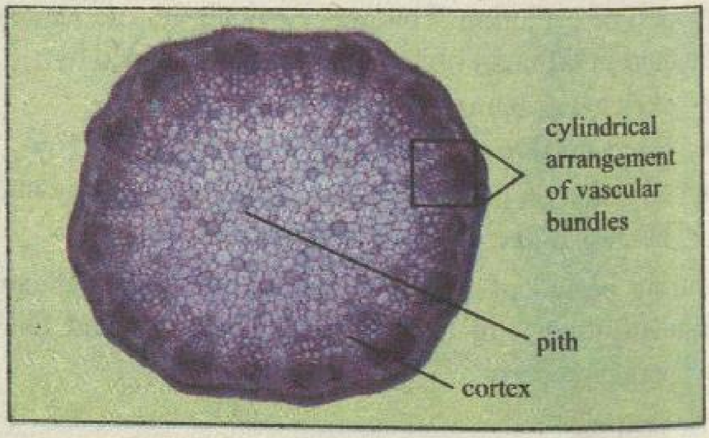
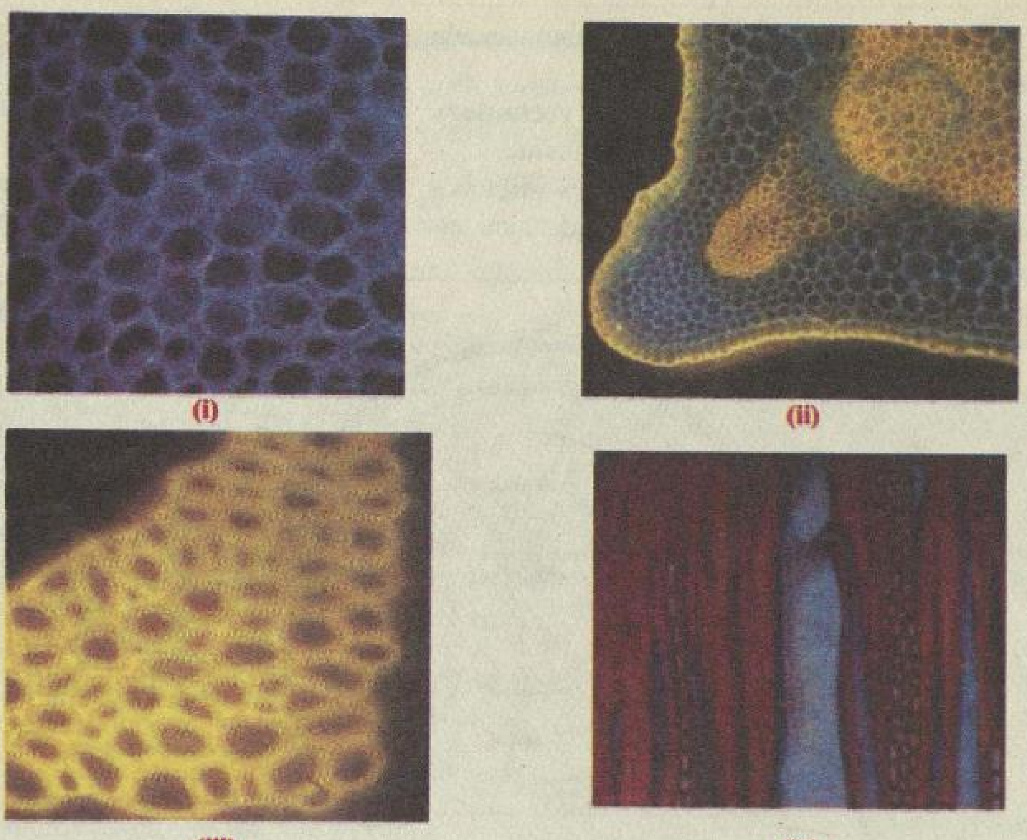


Fig. 14.1 T. S. of sunflower stem.



(i) (ii)

(iii) (iv)

Fig. 14.2 Supporting tissues of young dicotyledonous stem (i) Parenchyma (ii) Collenchyma (iii) Sclerenchyma (iv) Fibres

Spindle shaped dead thick walled **tracheids** and elongated **fibrous cells** found in xylem and phloem also provide strength to the stem (Fig. 14.3).

14.2.2 Supporting tissues of woody dicotyledonous stem

Supporting tissues of the woody dicotyledonous stem are **wood** and **bark**. They are produced from the activity of two types of meristematic tissues; **vascular cambium** and **cork cambium** respectively.

As a result of this secondary growth (chapter 2) following secondary tissues which increase the thickness of stem, are produced.

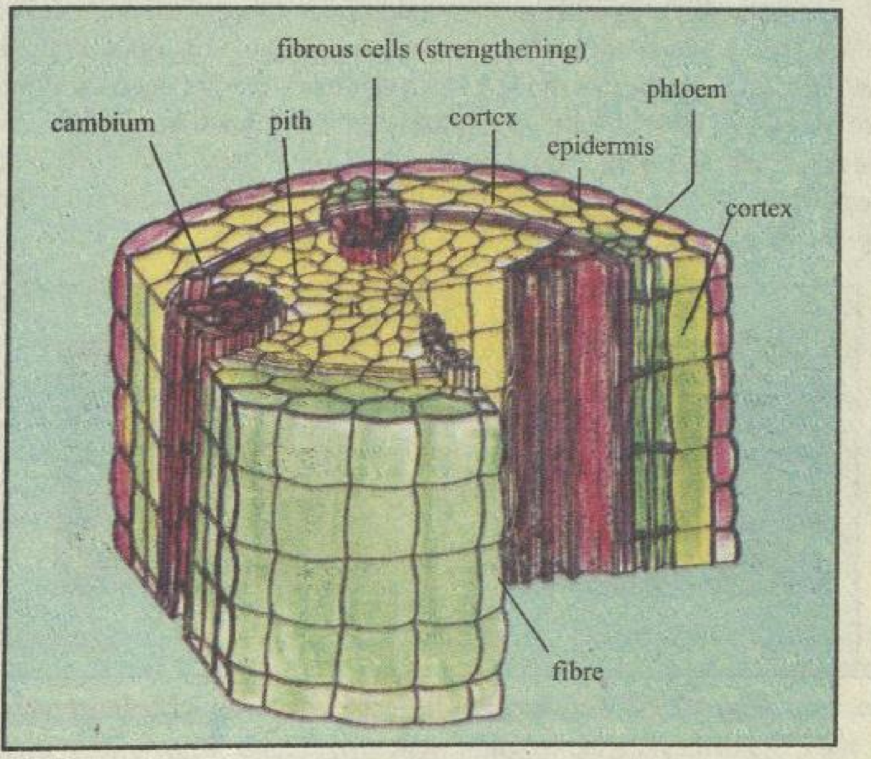

fibrous cells (strengthening)
phloem
cambium
pith
cortex
epidermis
cortex
fibre

Fig. 14.3 Section of a woody dicot. stem

- The **medullary rays** between the vascular bundles divide, forming a continuous cylinder of vascular cambium.
- The vascular cambium produces **secondary xylem** or **wood** towards the inside of the stem and **Secondary phloem** towards the outside.
- Expansion of the vascular tissues stretches and breaks the **epidermis and cortex,** which are ultimately lost. The dividing cells,derived from the phloem, form a cork cambium.

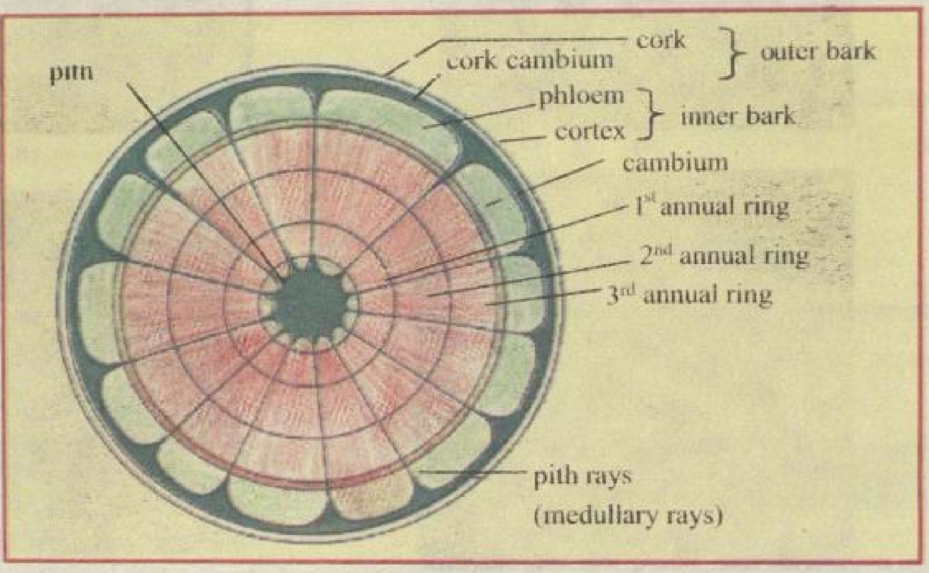


Fig. 14.4 The diagrammatic cross section of three years old woody dicotyledonous stem shows the internal arrangement of the supporting tissues

The cross section of woody dicotyledonous stem (Fig. 14.4) shows the following internal arrangement of tissues.

1. Bark

The **cork cambium**, a special layer of cells in the outer region, produces layers of cells with thickened water proof walls called **cork.** All the cells outside the layers of cork eventually die as it cuts off all food supplies to them. Cork together with the dead epidermis and cortex collectively form **bark** of the tree. This is quite a distinct outer region that provides support to the woody dicotyledonous stem. Cork and cork cambium form an outer bark and cortex and phloem form an inner bark. Cork cambium also produces spongy tissues – **lenticels** in the bark through which exchange of gases takes place [Fig14.5(i)(iii)].

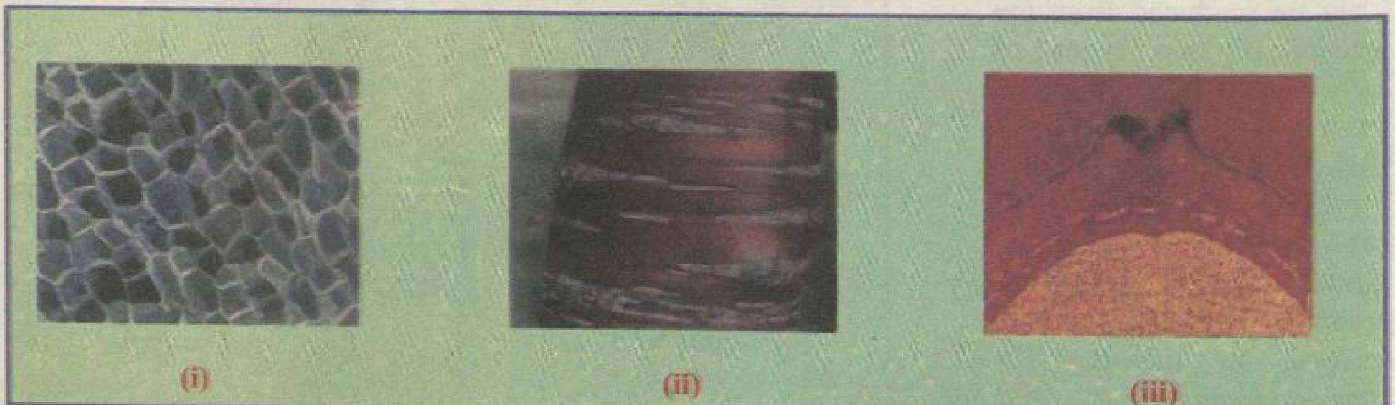


Fig. 14.5 (i) Cork cells (ii) Bark of a tree with lenticels (iii) Spongy tissues of lenticels

The rate of secondary growth in a stem varies with seasonal changes. This results in the formation of growth rings or **annual rings**, which may have a;

- **Autumn wood** as the xylem cells formed during autumn and winter i.e. during the period of slow growth, are small and thick walled.
- **Spring wood** as the xylem cells formed during spring and summer are large and have thinner walls during the period of fast growth.

In temperate countries, one growth ring in a stem shows both types of xylem tissue formed during one whole year. This is known as an **annual ring** and the age of the tree can be determined by counting the number of rings present. In tropical countries, growth rings are formed when favourable seasons alternate regularly with unfavourable seasons.

Practical Work: Microscopic examination of a young dicotyledonous stem and its comparison with woody dicotyledonous stem.

1. Prepared slides of cross section of young and woody stem: sun flower.
2. Observe with low power of a compound microscope, the prepared slides of cross sections of young (A)and woody sun flower(B) stems.
3. Compare your slides with the Fig. 14.1 and Fig. 14.4 respectively to become familiar with the general regions of both of the stems.
4. Draw a circle about 15 cm. in diameter with compass. Outline the vascular bundles and other regions as they appear in your slide A. Do not draw in any cell. Colour different regions as seen in above figures.
5. With high power of microscope, identify, and compare the structures and positions of supporting tissues of slide A and those of slide B.
6. Answer and write down the following questions in your note book.

Q. (i) Enlist the main supporting tissues of young and woody dicot stem.

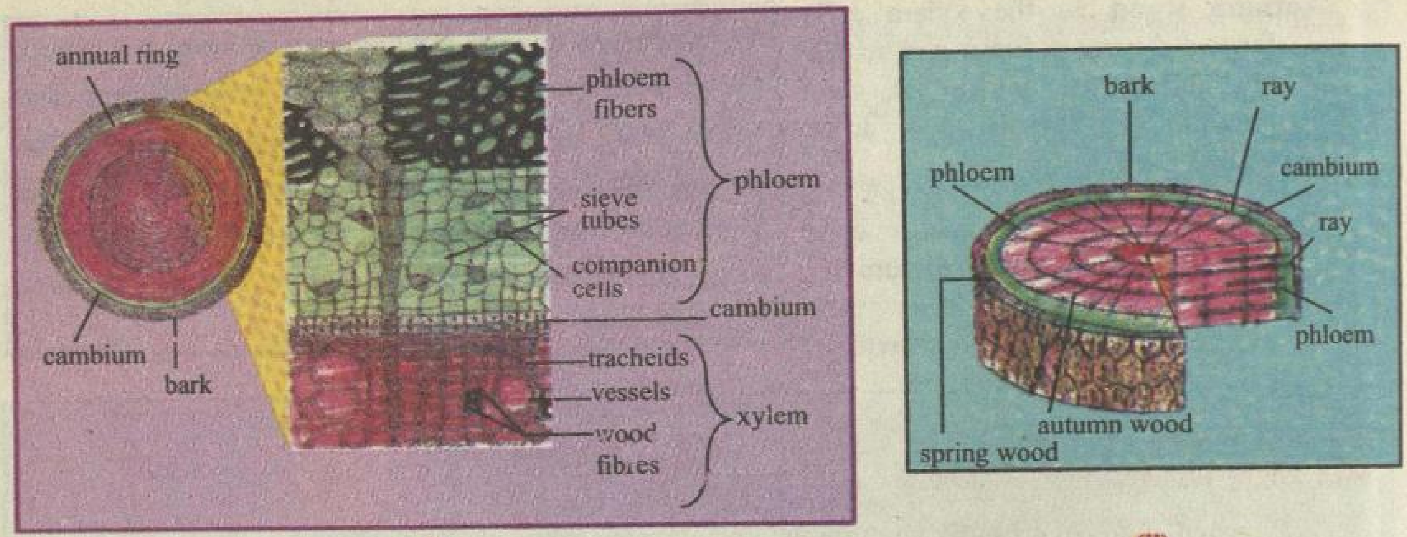
Q. (ii) Are the meristematic tissue present in both stems. If yes, name and write down their distinguishing features.

Q. (iii) Match the terms written under column A with those written under column B.

Column A	Column B.
Annual ring	Turgidity
Heart wood	Spongy tissue
Lenticel	Seasons
Parenchyma	Hard appearance

3. Cambium

This is a small ring of meristematic tissues between bark and wood, which is responsible for increase in thickness. During the spring and summer, cambium is active in producing new cells by division. It forms new phloem tissues on its outside surface and new wood tissues on its inside surface. During one season of cambium activity, many more wood cells than phloem cells are formed. That is why woody area of a tree is always much greater in thickness than that of its bark.


annual ring
phloem fibers
sieve tubes
companion cells
phloem
cambium
tracheids
vessels
wood fibres
xylem
cambium
bark
bark
ray
phloem
cambium
ray
phloem
autumn wood
spring wood

(i) (ii)

Fig. 14.6 Cross section of woody stems showing (i) annual rings ;woody tissues (ii) winter and autumn wood

Medullary Rays

Medullary rays or pith rays appear as lines radiating from the center to the outside of the wood like the spokes of a wheel and help in horizontal transport of food materials.

Pith

This is a central core which is later replaced by heart wood. It never increases in size. Regardless of the size to which a tree may grow, its pith never increases beyond the amount present during the first year of growth.

14.3 Movement in Plants

The behaviour of an organism is greatly affected by the responses it makes to both external (outside the body) and internal (within the body) stimuli. This ability of response to the stimulus is present in the **protoplasm** and is the characteristics of all the living organisms both plants and animals.

The direction of the stimulus has relationship to the direction of the movement of a plant or its parts. The response towards the stimulus is termed as **positive response** while that away from the stimulus is known as **negative response.**
The movements in plants are of following three types:

- Tactic Movement
- Nastic Movement
- Tropic Movement

1) Tactic Movement

In this type of movement the plant body as a whole moves from one place to another in response to external stimuli such as light, water, chemicals etc, e. g *Chlamydomonas* always move towards light of low intensity and away from light of high intensity.

This type of response is known as **positive phototactic response** and **negative phototactic response** respectively.

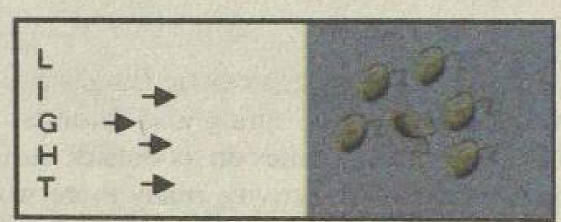


Fig. 14.7 Tactic Movement in *Chlamydomonas*

2) Nastic Movement

This is a movement made by a part of a stationary plant in response to external stimulus. Stimulus in this case influences the organ with equal intensity from all the directions.

Nastic movements are exhibited by bud scales and flower petals. These bend upwards due to fast growth on their lower surface. When the bud unfolds itself, the growth of its upper surface is faster than that of the lower surface, hence the petals bend downwards. In the case of *Ipomea* (Fig. 14.8) fading of the flower is due to the turgor changes in its rib cells. The cells in the inner side of the rib lose solutes and water while the outer rib cells expand, causing curling.

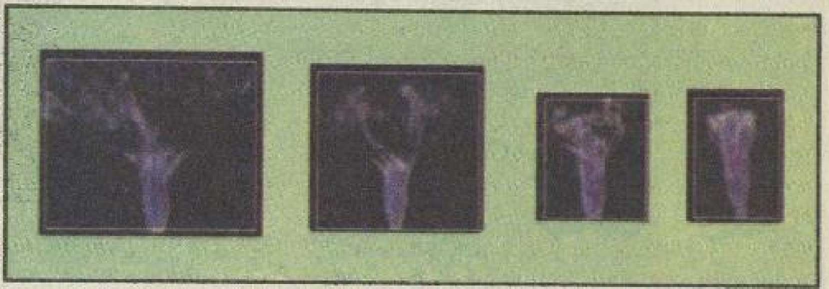


Fig. 14.8 Nastic movement in *Ipomea*

Similarly changes in the water contents of the tissues at the base of the leaf of *Mimosa* plant results in the shrinkage and folding of its leaflets. Such response may be due to different stimuli, such as light, touch, heat, or electric shock. After a suitable recovery period the leaflets open again. Normally they remained expanded in the day time while at night they are closed (Fig. 14.9).

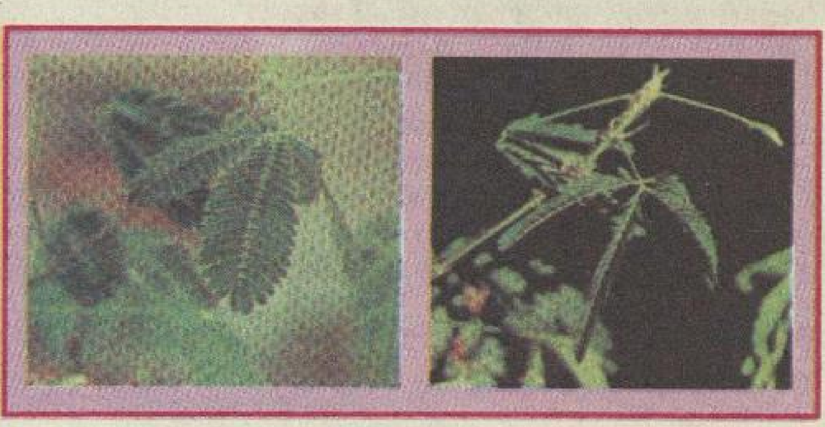


Fig. 14.9 Nastic Movement in the leaflets of *Mimosa* Plant

3) Tropic Movement

When the fixed part of the stationary plant moves in response to a stimulus the reaction is known as **tropic movement** or **tropism**. Stimulus in this case influences from some specific direction. These are growth movements as response against the stimulus is produced by a plant's growing points, the root and shoot apex. The growth movement is caused by an increased and decreased rate of growth on the side of the organ which is under the influence of the stimulus with respect to the opposite side.

The **negative tropic movement** occurs when the plant organ grows more rapidly on the side nearer to the stimulus so that it bends away from the stimulus. In case of a **positive tropic movement,** the side of the organ away from the stimulus grows more rapidly so the organ bends towards the stimulus.

Tropism or tropic movements are of following three types.

- Geotropism
- Phototropism
- Hydrotropism

Geotropism

The response shown by the tips of the shoots and roots of a plant to the stimulus of gravity is known as **geotropism.**

The growing shoot apex and the leaves response negatively to the gravity exhibiting **negative geotropism** [Fig. 14.10(ii)] while the apex of the main (primary) root responds positively to gravity exhibiting **positive geotropism** [Fig. 14.10(i)].

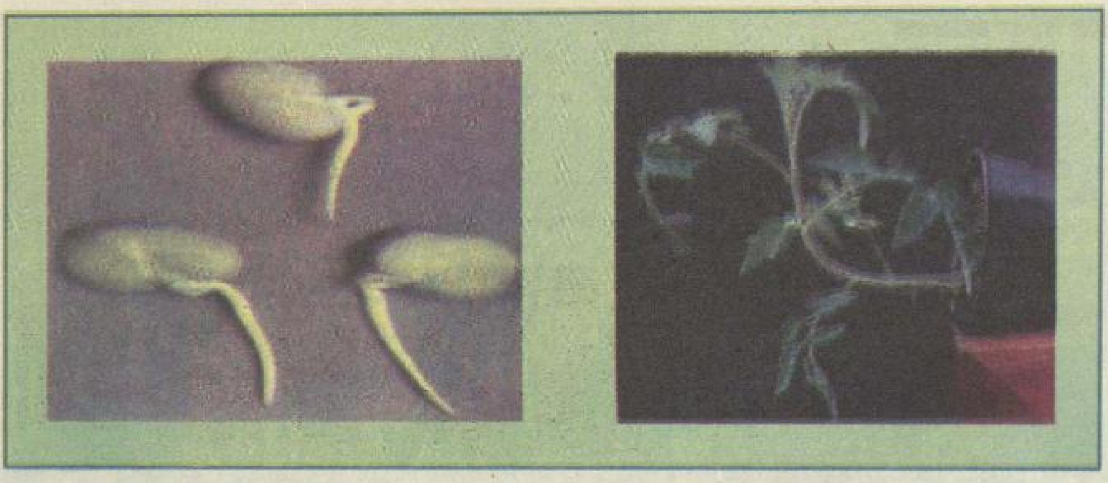


Fig. 14.10 (i) Positive geotropism (ii) Negative geotropism.

Negative geotropic response of shoots

1. Shoots which are negatively geotropic grow vertically and it helps the plant to compete for light and carbon dioxide.
2. The flowers are brought into an advantageous position for pollination through insects or wind.
3. Seed dispersal may be more effective on long and vertical stem.

Positive geotropic response in roots

1. It causes roots to grow downwards into the earth where they can anchor the plant firmly in the soil.
2. It causes them to obtain water and mineral salts.
3. Lateral roots, not positively geotropic grow at right angles or slightly downwards from the main root. This enables a large volume of soil to be exploited and helps to anchor the plants securely.

Phototropism

The response shown by the tips of shoots and roots of the plant to the stimulus of light is known as phototropism.

The growing shoots and leaves show a positive response exhibiting **positive phototropism** (Fig. 14.11) while the growing roots generally show a negative response exhibiting **negative phototropism.**

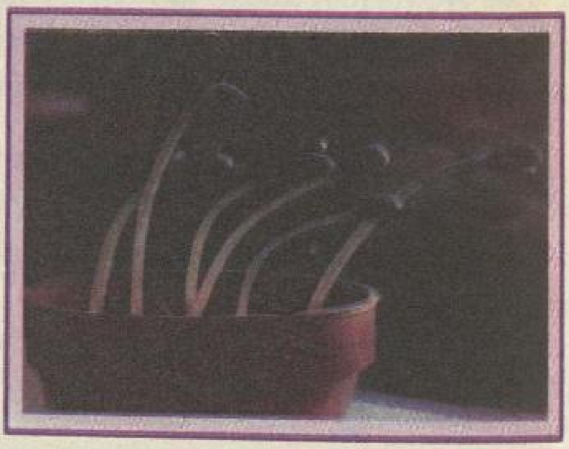


Fig. 14.11 Positive Phototropism

Positive Phototropic Response of Shoots

1. By growing towards the source of light, a shoot brings its leaves and stems to absorb the maximum amount of sunlight for photosynthesis and synthesis of chloroplast.
2. Flowers are brought into an exposed position where they are most likely to be seen and pollinated by flying insects.

Hydrotropism

The response of growing tissues of plant to the stimulus of water is known as **hydrotropism**.

Root apices i.e. tips respond positively towards water while shoot apices respond negatively.

In such cases as shown as shown in (Fig. 14.12), water is an even stronger stimulus than gravity.

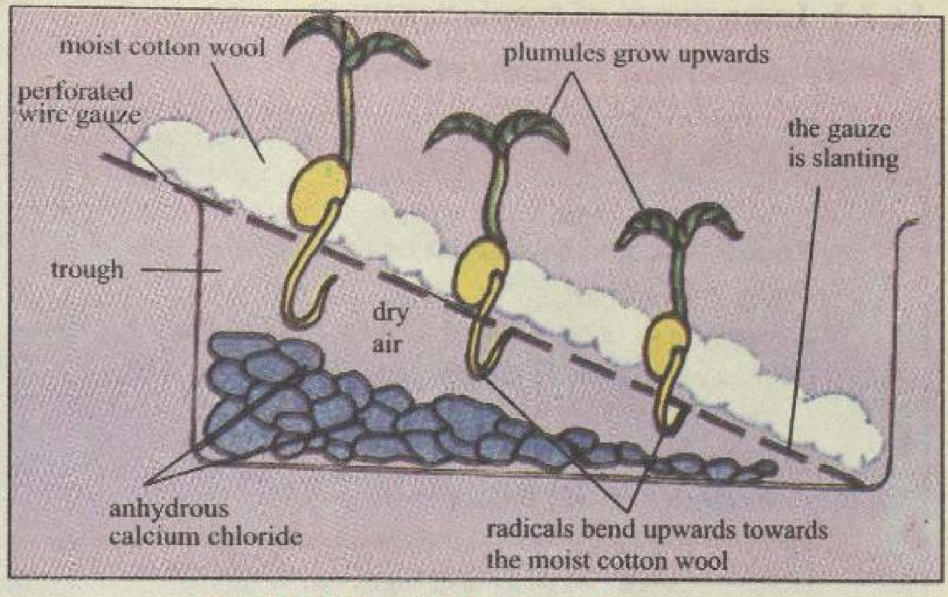
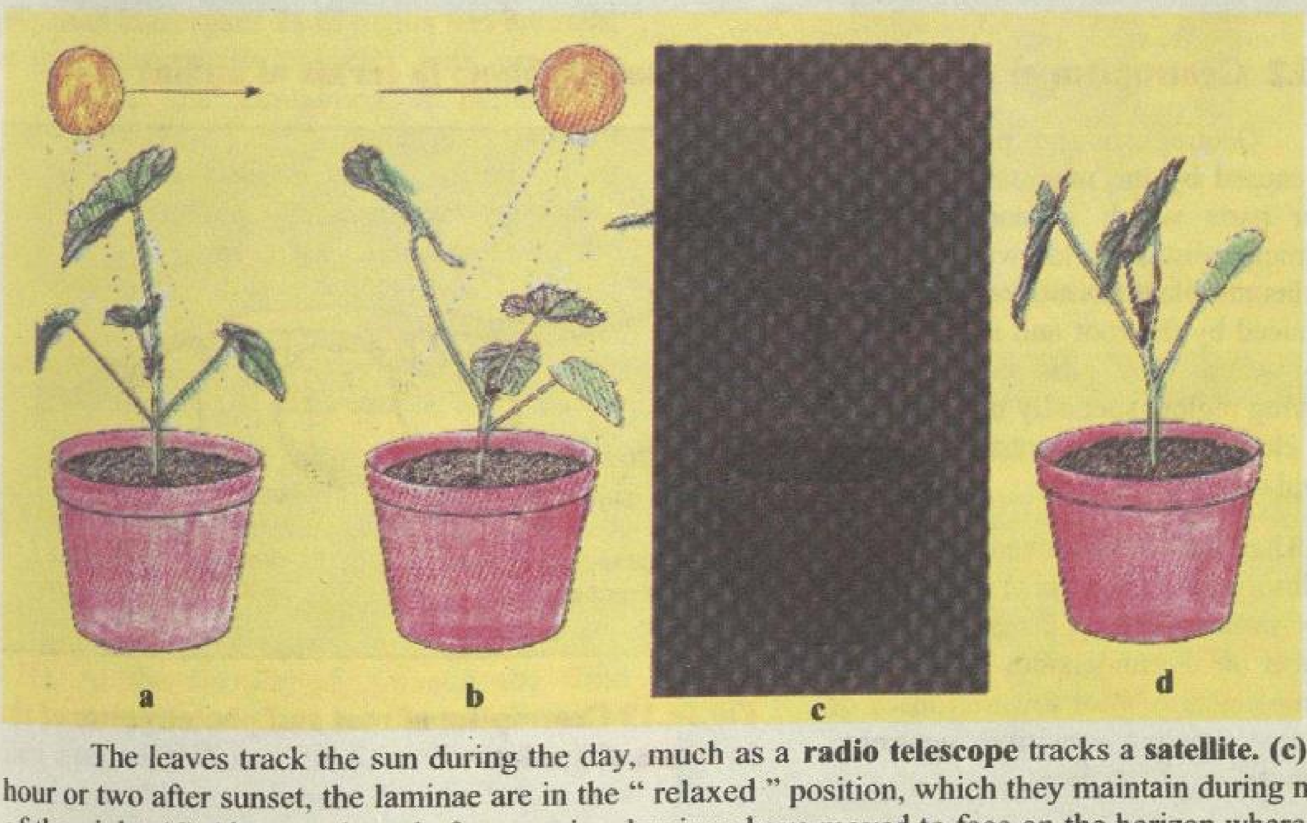

moist cotton wool
perforated wire gauze
plumules grow upwards
the gauze is slanting
trough
dry air
anhydrous calcium chloride
radicals bend upwards towards the moist cotton wool

Fig.14.12 Positive hydrotrpism

Many plants are capable of **solar tracking,** in which flat or cup shaped lamina of the leaf remains nearly at right angles to the sun throughout the day, maximizing the light harvested by the leaf. Solar tracking in some members of family Malvaceae e. g. Malva or Lavatera is shown below . The lamina in this case receive directional signals from the sun and tilt to face it as the tissues at its junction with the petiole, gain or lose water (**a** and **b**).



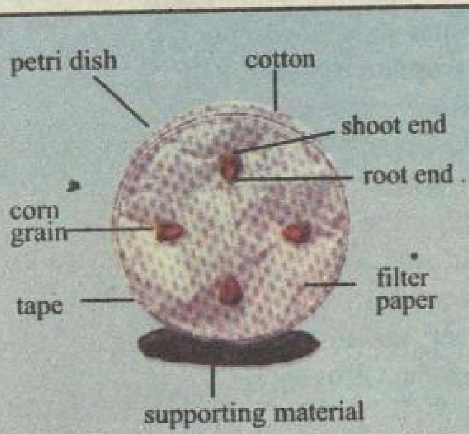
The leaves track the sun during the day, much as a **radio telescope** tracks a **satellite.** **(c)** An hour or two after sunset, the laminae are in the " relaxed " position, which they maintain during most of the night. **(d)** About an hour before sunrise, laminae have moved to face on the horizon where the sun will rise.

Isn't it an interesting phenomenon? Would you like to investigate it in leaves of other species like cotton, beans, alfalfa etc?

14.3.1 Importance of tropic response

Positive phototropic response of shoots

Practical Work: To investigate geotropism.


petri dish
cotton
shoot end
root end .
corn grain
filter paper
tape
supporting material

1. Place four soaked corn grains on the bottom of an empty petri dish.
2. Arrange them as shown in figure 14.12 with their pointed ends directed towards the center of the dish.
3. Cut a piece of filter paper to fit tightly inside the bottom of a petri dish.
4. Place the paper over the corn grains.
5. Pack the rest of the dish tightly with the wet cotton.
6. Cover it with other petri dish bigger than this and seal the edge with transparent tape.
7. Using a water proof marker, label the location of the seeds A, B, C, and D.
8. Stand the petri dish up on its side in a dark place and fix it down with any supporting material.
9. Make a sketch of the set up in your note book. Using different colours for the roots and shoots, sketch the daily additional growth, specially direction of the seedling.
10. Rotate the dish on one- quarter turn so that A is at B, B is at C, C is at D, and D is at A.
11. Allow the seedlings to grow for two more days. Continue recording your observations with sketches.
12. What is the general direction of growth of root tips and shoot tips?

14.3.2 Geotropism of root and phototropism of shoots in terms of auxins

Geotropism and phototropism are caused by the unequal growth of plant parts which is controlled by chemical substances, known as **auxins**. Auxins are plant hormones . They are produced by the root and shoot apices from where they pass down to the growing region, specially the region of cell elongation and exert their growth stimulating effects there.

The increased concentration of auxins on the lower side of the root apex results in the decreased rate of growth on the underside. This results in movement of root towards force of gravity showing positive geotropic response.

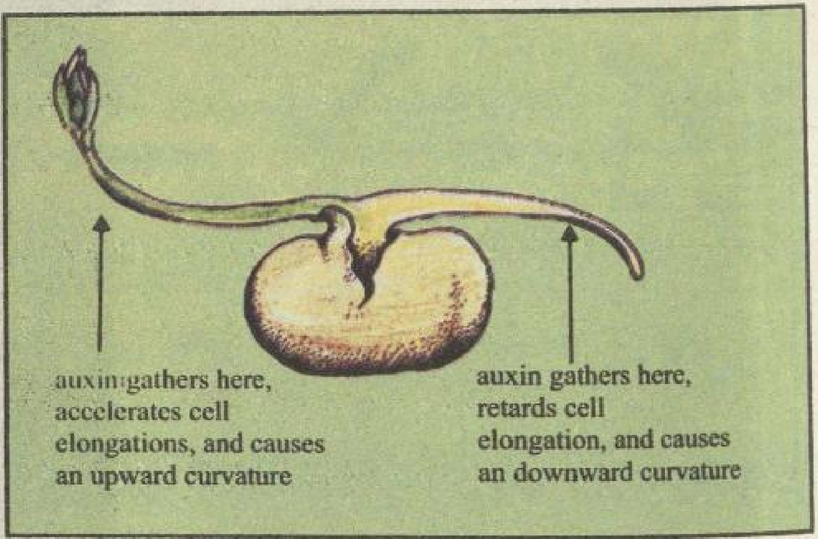

auxin gathers here, accelerates cell elongations, and causes an upward curvature
auxin gathers here, retards cell elongation, and causes an downward curvature

Fig.14.13 Geotropism of root and phototropism of shoot in terms of auxins.

14.4 Locomotion in Plants

Generally plants are incapable of locomotion. But some photosynthetic protists move from one place to another with the help of flagella e.g. *Euglena* and *Volvox*.

14.4.1 Locomotion in *Euglena*

Locomotion in *Euglena* takes place by the lashing movements of a single long, whip-like flagellum, against the surrounding water. This whipping action of the flagellum causes it to rotate and at the same time to move forward. Some times it may show a slow wriggling movement due to alternate contraction and relaxation of the long thread like structures present in the cytoplasm. This type of movement displayed by *Euglena* is known as euglenoid movement. *Euglena* does not move in a straight line but it moves in a zig zag path along with rotation on its own axis.

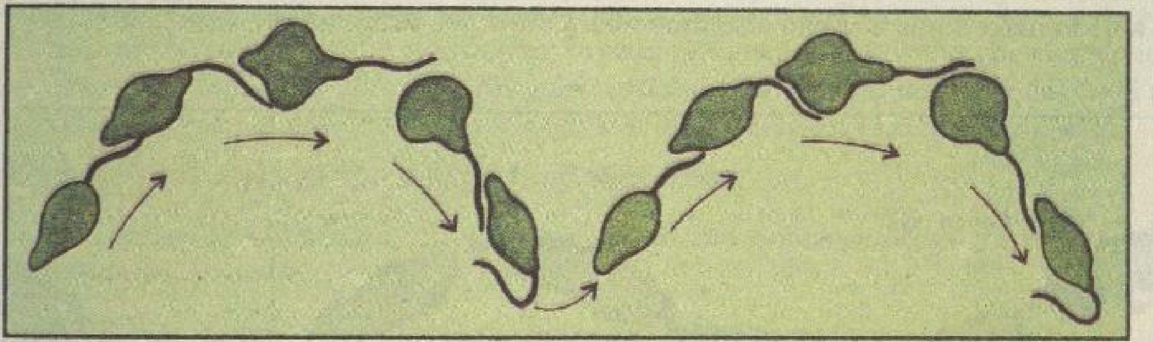


Fig. 14.14 Locomotion in *Euglena*

14.4.2 Locomotion in *Volvox*

Volvox freely floats or rolls over the surface of water looking like a minute ball of pin head size. The cells are not differentiated into tissues and organs as in plants and animals, but they form motile colonies with precisely spaced cells and containing a number of daughter colonies. The locomotion is brought about by the simultaneous action of cilia of all the cells of the colony. The eye spot - the photo-receptive organ, of each cell controls the movements of flagella.

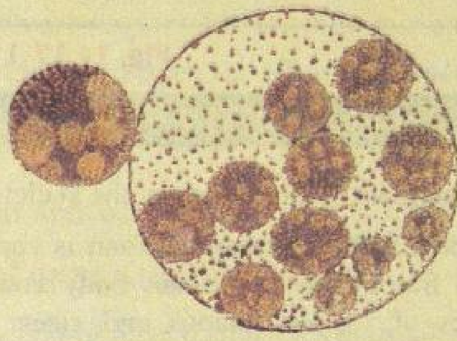


Fig. 14.15 Locomotion in *Volvox*

14.5 Support and Movement in Animals

Animals have to move from one place to other in search of food and shelter.

14.5.1 Locomotion in *Amoeba*

Amoeba has no special locomotory organs like flagella or cilia. It moves by the flowing movement of its protoplasm over its surface (Fig. 14.21). At the surface of *Amoeba* the fluid cytoplasm begins to flow out into a projection called a pseudopodium. The flow of whole of the protoplasm, ultimately brings *Amoeba* into a new position. Change of direction takes place when a new pseudopodium begins to form at another point of its surface. Direction of movements is probably determined by local differences in water. Slight acidity or

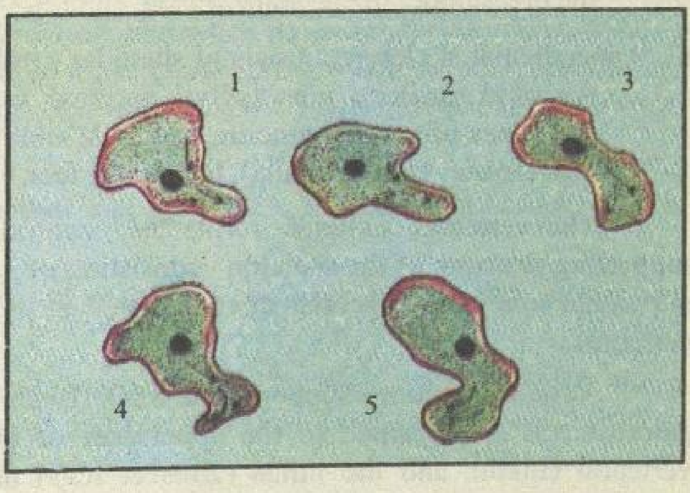


Fig. 14.16 Locomotion in *Amoeba*

alkalinity may cause the protoplasm to start flowing or prevent moving of *Amoeba*. The chemicals diffusing from required material may cause the protoplasm to flow in that direction.

14.5.2 Locomotion in *Paramecium*

Paramecium moves about at great speed. It moves with the help of its cilia which continuously beat against the water in a diagonal pattern. These cilia move forward and backward like the oars of a boat. The body of the *Paramecium* twists itself slightly and moves forwards as a result of the collective action of all the cilia. In other words body rotates on its axis while it moves forward. The animal is able to make turns and can also move backward by changing the direction of movement of its cilia.

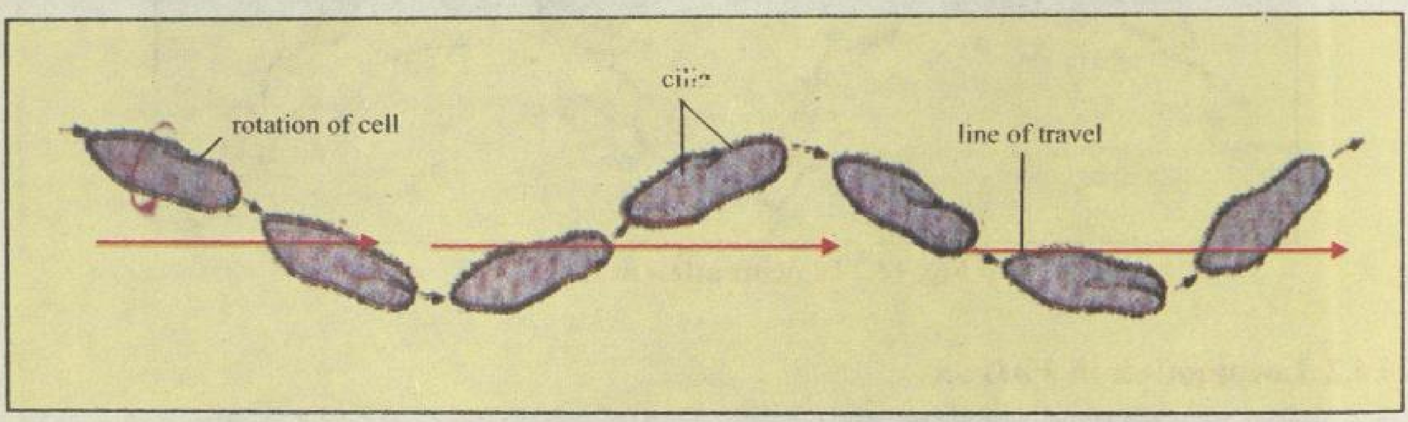

cilia
rotation of cell
line of travel

Fig. 14.17 Locomotion in *Paramecium*

14.6 Support and Movement in Man

In higher animals, including man, the skeleton provides support, protection and helps in movement.

Support and movement in man is carried out with the help of skeleton and muscles. Skeleton is a hard framework of human body consisting of 206 bones of various shapes and sizes; long and short; flat or irregular. Skin and muscles form the external covering of the skeleton. Skeleton of man is divided into two major divisions:

- Axial skeleton consists of the skull, the backbone (vertebral column), and the ribs. The backbone supports the ribs which are also attached to the breastbone, or sternum.
- Appendicular skeleton consists of shoulder girdle (pectoral girdles), hips (pelvic girdles) and the bones of arms (humerus, radius & ulna), legs (femur, tibia & fibula), hands and feet.

The vertebral column forms the central supporting structure of the skeleton consisting of 33 individual bones called **vertebrae** (singular-vertebra).

Vertebral column supports the skull. Twelve pairs of ribs are attached to the upper part of the vertebral column and the limbs (arms & legs) are attached to it by means of girdles.The pelvic girdle is

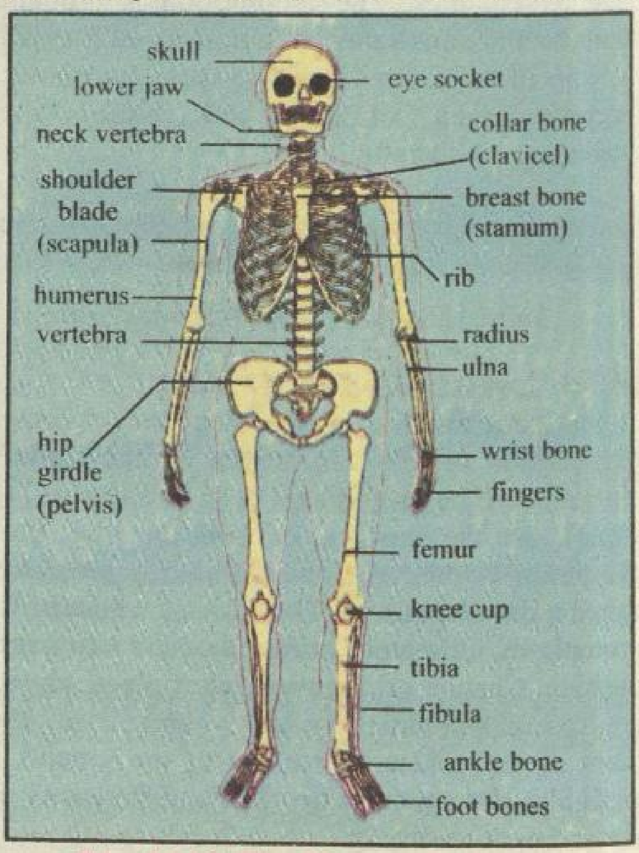

skull
lower jaw
neck vertebra
shoulder blade (scapula)
humerus
vertebra
hip girdle (pelvis)
eye socket
collar bone (clavicel)
breast bone (stamum)
rib
radius
ulna
wrist bone
fingers
femur
knee cup
tibia
fibula
ankle bone
foot bones

Fig. 14.18 The Human Skeleton

joined rigidly to its lower end. Pectoral girdle consists of a pair of collar bones and shoulder blades, which are not rigidly fixed to the vertebral column but held in place by muscles (Fig. 14.18).

14.6.1 Functions of skeleton in support and movement

Support

The skeleton holds the body off the ground and keeps its shape and helps in movement.

Movement

Many bones of the skeleton act as levers. When muscles pull on these bones, they produce movements such as the raising of the ribs during breathing (chapter 11) or the chewing action of the jaws and flexing of the arms. For a skeletal muscle to produce movement, both its ends need to have a firm attachment. The skeleton provides suitable points of attachment for the ends of muscles.

14.6.2 Muscles play role in the support of skeleton

The skeletal muscles which are firmly attached to the bones play an important role in the support of skeleton for example:

- The muscle that lie at the back hold the backbone and the head in place.
- The diaphragm, a muscular sheet that divides the body cavity into two parts, is attached to the lowest rib bones. The muscles of the diaphragm and those connecting the ribs to one another, collectively forming part of the rib cage and are responsible for breathing.
- The limbs are connected to the girdles by muscles, which are responsible for their movement.
- The upper arms and thighs have muscles that are able to close and open the elbow and knee.
- The fore arms and shanks have muscles that are responsible for the movement of the hands and feet.
- Numerous muscles control the manipulation of the fingers and toes.

14.6.3 Action of flexors and extensors as a pair of opposing muscles

Muscles are attached to the bones at two points. One end of a set of muscles is usually attached to an immovable and rigid bone while that of the other is attached to a movable bone. The first point of attachment is known as the **origin** of the muscle and the second as its **insertion.** Muscles may have more than one origin. Muscles may be attached directly to the bone or indirectly by means of tough, whitish cords of fibrous material called **tendons.** Muscles can only contract and relax but not expand. When a muscle contracts, it becomes shorter and thicker and hence exerts a pulling force on the bone to which it is attached at the point of insertion. When a muscle relaxes, it lengthens and becomes thinner. Muscles work by contraction only. To move a bone to and fro, there are two sets of muscles. When one set contracts, it moves the bone in one direction, and when the other set contracts, it moves the bone in the opposite direction i. e. these two sets of muscles are **antagonistic** to each other. When one member of antagonistic pair of muscles contracts, the other relaxes. Such movement is known as **antagonistic movement** or **antagonism**.

- Bending of the arm at elbow joint is called **flexion** and the muscle that causes this movement is called **flexor.**
- Straightening of the arm at elbow joint is called **extension**, and the muscle that causes this movement is called **extensor.**
- One member of the pair of antagonistic muscles at elbow joint (Fig. 14.18) is: the **bicep muscle** that lies in front of the humerus, its upper end has two tendons (hence the name biceps) which have their origin on the shoulder blade of pectoral girdle. The lower end of the bicep has a single tendon attached to the radius.

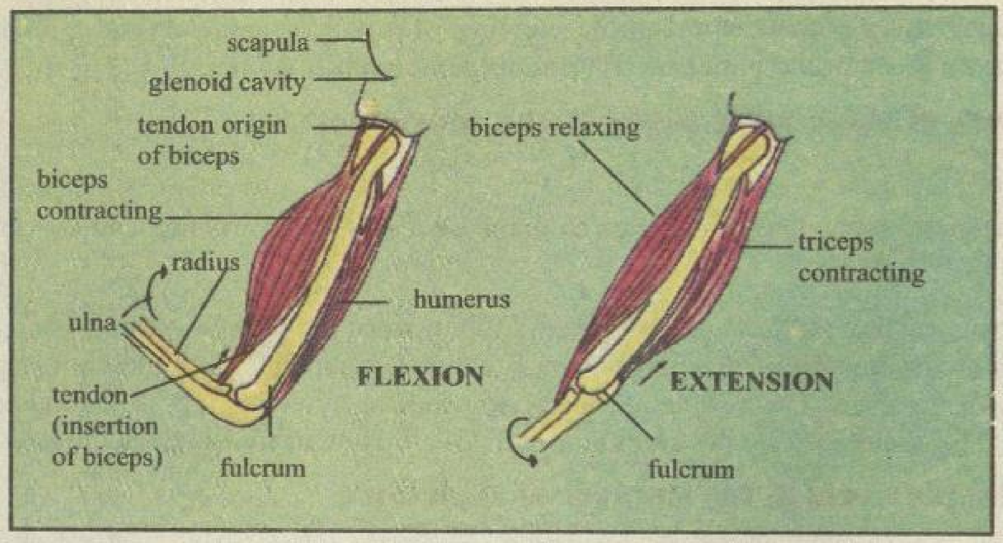

scapula
glenoid cavity
tendon origin of biceps
biceps contracting
radius
ulna
tendon (insertion of biceps)
fulcrum
humerus
FLEXION
biceps relaxing
triceps contracting
EXTENSION
fulcrum

Fig. 14.19 Action of Antagonistic sets of muscles at elbow

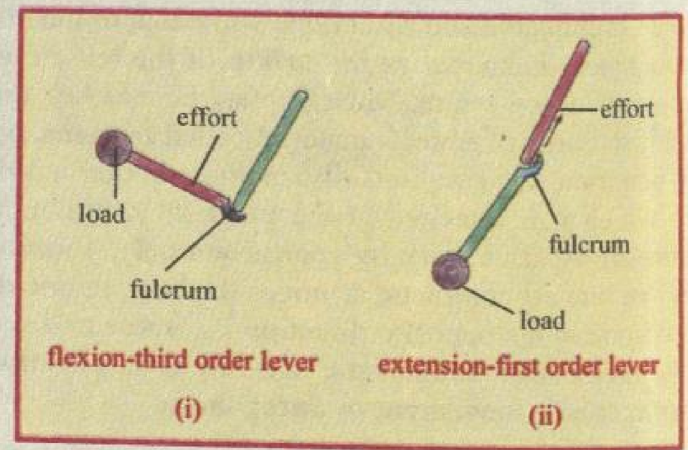
- The **tricep muscle** that lies behind the humerus. It has its origin on the shoulder blade and humerus as three tendons, hence the name triceps. Its lower end continues as a single tendon inserted on the ulna.

The **contraction of the biceps** causes the forearm to be pulled upward This flexion of the forearm at the elbow is effected only when the triceps muscle relaxes at the same time as the biceps contracts. Similarly, **contraction of the triceps** and relaxation of the biceps bring about extension or straightening of the forearm at the elbow joint.

14.6.4 Principle of Leverage and an elbow joint

A lever is a rigid rod pivoted at a fixed point, the fulcrum. It is able to move about this point under the action of opposing forces. Bones, especially, the long bones, are like rigid rods capable of moving against another bone at a joint (the fulcrum) under the pull of muscle.

- A first order lever has the fulcrum situated between the load and the effort.
- In second order levers, the load lies between the fulcrum and the effort.
- In the case of third kind of lever, effort is between the load and the fulcrum.The principle of leverage with reference to the elbow joint (fulcrum)of the arm shows that:
- The **flexion** or bending of the arm may be considered as **third order lever** in which effort is between fulcrum and load (Fig. 14. 19).
- While its **extension** or straightening represents the first order lever. In this type of lever, fulcrum lies between load and effort (Fig. 14.20).


effort
load
fulcrum
effort
fulcrum
load

flexion-third order lever (i)

extension-first order lever (ii)

Fig.14.20 Principle of leverage at elbow joint (i) flexion or bending of the arm – third order lever (ii) Extension or straightening of arm – first order lever

The mechanical advantage or disadvantage of the bones working as levers depends on the position of the fulcrum. The nearer the fulcrum is to the load, the easier it will be to lift the load, i. e. the greater the advantage will be. There will be a great disadvantage if the fulcrum is very near the effort. Bones usually act across joints in such a way that bones are worked as levers with a low mechanical advantage. The muscle can contract only a short distance, but because they are attached near to the joint, the movement at the end of the limb is greatly magnified. The biceps muscles of the arm may contract only about 10 cm, but the hand will move about 60 cm. From figure14.19 it can be seen that a small contraction of the biceps muscle (the effort) can produce a large movement of the fore arm (the load) around the elbow joint (the fulcrum).

14.6.5 Functions of tendons and ligaments in relation to Movement

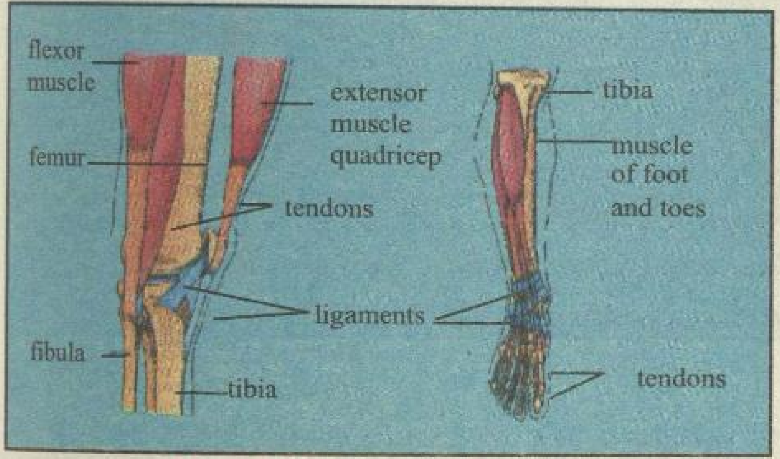


Fig 14.21 Tendons and Ligaments

Many of the muscles that extend your toes are actually in your lower leg. The tendons from these muscles travel over the front of your ankle, across the upper surface of the foot bones, and attach to the bones of your toes. Straps of ligaments over the ankle hold these tendons in place and allow them to bend at a right angle and elevate foot and toe.

You have already studied above that the ends of the muscles are drawn out into tendons. These are straps of connective tissues which attach each end of the muscle to the skeleton. One end of the muscle is attached to a non-moving bone of the skeleton, through tendon. The other end is attached to the movable bone close to the joint.

The relevant bones of the joints are held together by ligaments. These are strong flexible bands of connective tissues. The ligaments prevent dislocation during normal movement. They also hold tendons in place and control their direction

14.6.6 Joints ; Location and their Movements

When two bones meet, a **joint** is formed. They are movable or immovable.

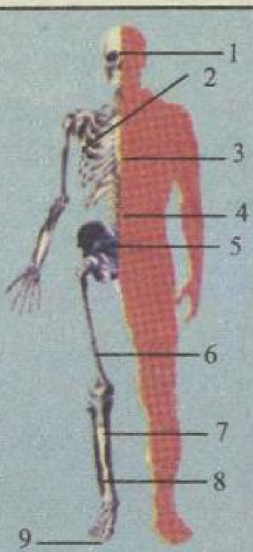
- The joints between the bones of the skull are fixed. They do not show any movement.

  In the case of the vertebrae, only a very limited movement can occur.

- The **ball-and-socket joints** of the shoulder and the hip allow movements in three directions; forwards, backwards and sideways.

- The **hinge joints** of the elbow and knee allow movement in only one plane (Fig. 14.23). The surfaces at the heads of the bones which move over each other are covered with a tough, slippery and smooth cartilage. This together with a liquid formed in the joint allows friction free movement.

Practical Work: To examine parts of human skeleton.



Examine human skeleton and answer the following questions

1. Categorize numbered bones of:
   (Write numbers only)
   (a) axial skeleton. Write down ____________________
   ____
   (b) appendicular skeleton. ____________________
   ____
2. How many ribs are attached to the vertebral column? ____________________
3. Name the bone, by means of which fore arm is attached to the vertebral column. __________
4. Encircle hinge, ball and socket joint on the given diagram of human skeleton (Fig. 14.18).

14.6.7 Defects of skeleton system

(a) Changes in bones

Bones become thinner, weaker and less flexible with aging. This is partly because required calcium level starts decreasing at the age of 35 years. This happens to every body to some extent. In some people it is particularly serious. In such cases it results in a condition known as **osteoporosis** or softening of bones.

Although whole of the skeleton is affected by osteoporosis yet hips, wrists and vertebrae tend to be affected worst of all. Even a minor fall can result in broken bone.

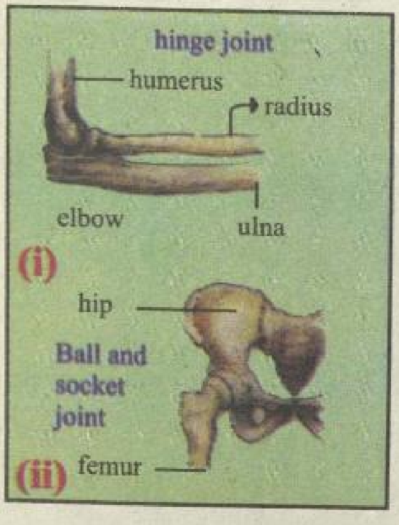


Fig. 14.22 (i) Ball and Socket Joint (ii) Hinge joint

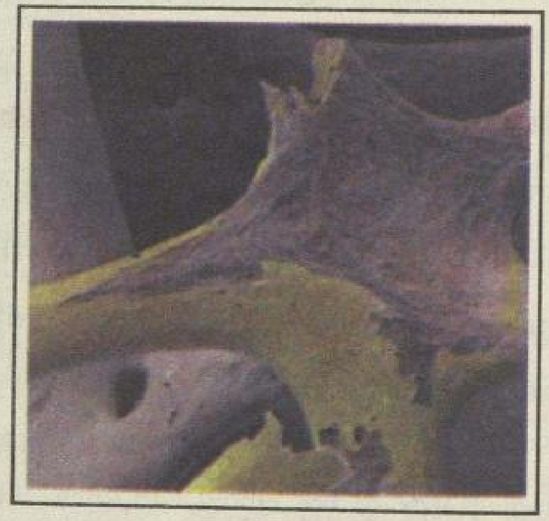


Fig. 14.23 Scanned electron micrograph of brittle and spongy fractured femur from a patient with osteoporosis. The dark areas show the affected portions of the bone.

Apart from the fractures, weaker bones in the spine may result in the:

Compression in the bones and intervertebral discs.
Loss of height.
Collapse of vertebrae causing bending of spine.

Osteoporosis or softening of bones is most common in elderly women affecting about 1 in 4 over the age of 60. A balanced diet rich in calcium and regular exercise helps to keep bones strong.

(b) Changes in Joints

The load bearing joints such as knees and hips particularly show changes. Like fingers joints, they become stiff and painful.

- Osteoarthritis is a complex joint disorder(Fig 14.24). As ageing progresses, the smooth tough **cartilage** which covers the ends of bones at joints becomes weaker and less extensive. It gradually breaks down. In extreme cases, the ends of the bones may become exposed. They start to grate against each other. This results in swelling and deformation of joints.
- In some cases **membrane** of the joints become thick. The joints swell and become stiff causing pain.
- Some times excessive use of protein may result in the deposition of **uric acid** at joints causing swelling and pain.

A less frequent type of joint degeneration known as rheumatoid arthritis is common in older people than in young people. It is an auto-immune disease in which body's immune system attacks its own tissues. Affected joints becomes hot and swollen during attacks.

(c) Dislocation of Joints

This is the displacement of one or more bones at a joint, caused by injury and sometimes by muscular action.

A severe sickening pain, abnormal appearance of joint along with swelling shows the dislocation of joints.

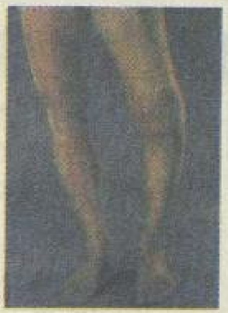


Fig. 14.24 A severe case of osteoarthiritis in the left knee of a man showing the swelling and deformation of joints.

KEY POINTS

1. Support in man; woody and non-woody parts of plant is due to skeleton; various mechanical tissues and presence of water in their parenchymatous cells besides cylindrical distribution of conducting tissues respectively.
2. Movement is a response shown by a part of living organism towards or away from the stimulus while locomotion refers to the movement of whole organism from one place to another under the influence of stimulus.
3. Supporting tissues of woody dicotyledonous stem is due to the secondary growth or thickening. This give rise wood and bark from the activity of vascular cambium and cork cambium respectively.
4. Movement of plant body as a whole is known as tactic movement. The movements of parts of plant towards or away from the stimulus is known as positive and negative tropism. The stimulus in this case is only from one direction.
5. Tropism may be of three types; Geotropism, Phototropism and Hydrotropism, the response is due to stimuli, force of gravity, light and water respectively.

6. Nastic movements in parts of the plants are affected by a stimulus from all directions e. g. folding and unfolding of buds or leaves.

7. Geotropism and phototropism are caused by a growth regulating substance or hormone called auxin.

8. Investigations proved that auxins produced by the root and shoot apices caused the growth responses below these apices.

9. Locomotion in *Euglena* is by a single whip like flagellum while that of *Volvox* by simultaneous action of flagella of all the cells of colony.

10. Locomotion of movement in *Amoeba* is brought about by the flow of cytoplasm in finger like processes, pseudopodium. *Paramecium* moves with the help of cilia.

11. Skeleton in man is of two types: axial and appendicular. It supports the body and helps to produce movements with the help of muscles.

12. Muscles play an important role in the support of skeleton and responsible for the movements of parts of the body.

13. Action of biceps (flexor) and triceps (extensor) brings about bending and straightening of the limb and is known as antagonistic movement of the forearm.

14. Tendons attach each end of the muscle to the skeleton while the relevant bones of the joints are held together by ligaments.

15. Elbow joint acts like a lever with the low mechanical advantage.

16. Ball and socket joints of shoulder and hip allow movement in three directions, forward, backwards and sideways. The hinge joints of elbow and knee allow movement in only one plane

17. Defects of skeletal system may be due to changes in bones and joints in old age causing diseases osteoporosis and osteoarthritis respectively.

18. Dislocation of joint is the displacement of one or more bones at a joint.

QUESTIONS

1. **Fill in the blanks.**
   - (i) A joint that permits to swing an arm in a circle is called ________ joint.
   - (ii) The skull, ribs and vertebral column are parts of the ___________ skeleton.
   - (iii) The bark in the woody dicotyledonous stem is produced due to the activity of __________ cambium.
   - (iv) The movement of the root towards the water is known as ________.
   - (v) When a muscle________, it becomes shorter and thicker.

2. **Write whether the statement is "true" or "false" and write the correct statement if it is false.**
   - (i) The axial skeleton includes the bones of the arms and legs.
   - (ii) The *Paramecium* moves with the help of flagella.
   - (iii) Some times excessive use of protein may cause pain and swelling at joints.
   - (iv) The heart beat is a movement that occurs at cellular level.
   - (v) The skull forms the central supporting structure of the skeleton.

3. **Each question is followed by four options. Encircle the correct answer.**
   - (i) Which of these pairs of joints in a human body allows movement in all direction?
     - (a) Shoulder and knee joints
     - (b) Hip and elbow joints
     - (d) Hip and shoulder joints
     - (e) Elbow and knee joints
   - (ii) Which organism moves by means of pseudopodia.
     - (a) *Paramecium* (b) *Euglena*
     - (c) *Amoeba* (d) *Volvox*
   - (iii) Movement of roots towards the force of gravity is known as:
     - (a) phototropism.
     - (b) negative geotropism.
     - (c) geotropism.
     - (d) positive phototropism.

(iv) Rotational and forward movement of *Euglena* is mostly due to:

(a) cilia (b) flagella

(c) pseudopodia (d) flow of cytoplasm

(v) Cylindrical arrangement of vascular bundles provides support in:

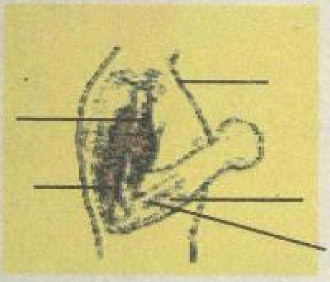
(a) woody dicot stem

(b) young dicot root

(c) young dicot stem

(d) woody dicot root

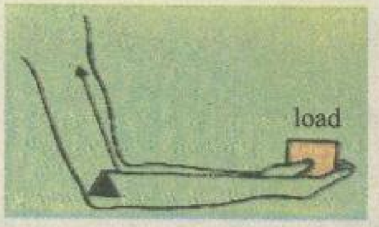
4. Identify and label the following diagram



5. Define auxin. Describe geotropism of root and phototropism of shoots in terms of auxins.

6. Give a comparative account on a tendon and a ligament with the help of labeled diagrams.

7. What does the given diagram (Fig. 14G) show. Write a brief note on it.



8. Describe the function of skeleton in support and movement.

9. How do the muscles play an important role in the support of skeleton?

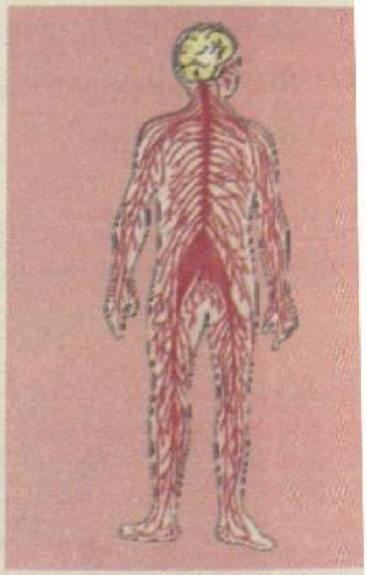
10. Define wood. Enlist the things made of woody stem which you see in your every day life.

15

COORDINATION

In this chapter you will learn:

- Concept of coordination
- Component of nervous system
- Concept of reflex action and reflex arc
- Different receptors in man
- Endocrine glands in man
- Abuse of drugs and their effects on man
- Disorder of nervous system
- Chemical control in plants



15.1 Introduction

In organisms, various organs and systems participate and play their role as and when required. Every organ of an organism does not work continuously except the heart, brain and lungs, which according to their role in the body are required to work 24 hours a day.

You can imagine what a bizarre scene it would present, if you want to lift an object in which you are required to use your both hands but your hand do not follow your command or if one of your hand is trying to lift it and the other hand is opposing it at the same time, their would surely be a chaotic situation.

For proper functioning of the body of an organisms, it is therefore, necessary that various organ and system work only when required, do their right type of job and also should not overdo or under do their jobs. When more than one organs are involved in an activity all the organs should operate in a sequence for the successful accomplishment of that particular function. All these attributes of physiology can be achieved when the body works as one unit, in which its different organs and systems cooperate and work in harmony with each other, i.e. its various functions are coordinated. Their coordination can ensure the successful existence of the organisms.

In animals co-ordination is produced by two systems.

(i) Nervous system
(ii) Endocrine system or chemical coordination

In both types of co-ordinations, the change (stimulus), whether external or internal is perceived by special organs which are called sensory organs. Any activity of an organism, when analyzed can be found to consist of responses. A response is a reaction to some action which takes the form of a stimulus. The stimuli are changes in the environment both external and internal. The change in the environment already mentioned is perceived/felt by special organs of the body, which are specialized to receive efficiently a particular type of stimulus. As for example the sound waves are received by ears. The stimuli of light are received by eyes, the stimuli of smell are received by nose, so on and so forth. That organs which are specifically build to receive particular type of stimuli are called **sensory organs or receptors.**

The information about the stimuli is then conveyed to the brain or spinal cord through neurons or nerves and to the endocrine glands through the blood. The brain or spinal cord and endocrine glands play their role according to the stimuli. The former sending message about the action or response to be made by particular organs. The later by secreting hormones which are poured into blood and transported to the special organs or target organs which produce the response. The organs producing particular responses are known as **effector organs**, which are muscles and glands.

$$\text{Stimuli} \longrightarrow \text{Receptors} \xrightarrow[\text{is carried by sensory neurons}]{\textbf{Information about the stimuli}} \textbf{C.N.S.} \xrightarrow[\textbf{carry orders}]{\textbf{Motor nerves}} \textbf{Effectors}$$

(muscles or glands)
produce the appropriate response

Stimuli → Endocrine gland → Secrete hormones in the blood → Target organ which produces the appropriate response

15.2 Nervous Coordination

As already mentioned nervous coordination is brought about through the various elements of the nervous system which are:

(i) Receptors
(ii) Sensory neurons or nerves
(iii) Central neurons system (brain and spinal cord), made of associative neurons (inter-neurons)
(iv) Motor neurons or nerves
(v) Effector organs

The stimuli are received by the receptors which convey the messages to the CNS through sensory neurons or nerves. CNS consolidates the information of stimuli, comprehends it and formulates the type of response to be produced. The messages of the type of response are passed via motor neurons or nerves to the particular effectors which produce a specific response.

Nervous coordination is usually involved in producing rapid and short lived responses.

15.2.1 Components of nervous system

1. Neurons (nerve cells)

The structural and functional unit of the nervous system in all animals including man is the neuron. This is a highly specialized cell which contains the typical organelles found in most eukaryotic cells. This cell is highly adapted for communication because of its wire like projection, the dendrites which are often further branched and carry impulses towards the central cell body. The cell body is a thicker region of the neuron containing the nucleus and most of the cytoplasm. The axon is the projection, generally very long, that carries impulses away from the cell body. Usually a neuron has a single axon. Fatty substances covering the axon is the myelin sheath along with short regions of exposed axon are called **nodes of Ranvier**. Many axons and even dendrites combine to form a single nerve.

Neurons are of three types.

a) Sensory neurons: They carry nerve impulses (message) from receptors to central nervous system.

b) Motor neurons. They carry nerve impulse (orders) from central nervous system to effectors.

c) Associated neurons: They form central nervous system and are responsible for analyzing the message and issuing orders.

Examine a photograph/slide of a neuron and compare its structure with Fig. 15.1.

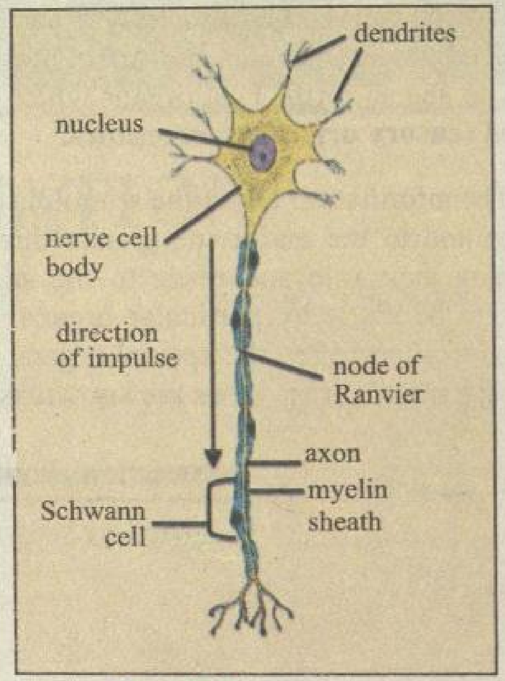

dendrites
nucleus
nerve cell body
direction of impulse
node of Ranvier
axon
myelin sheath
Schwann cell

Fig 15.1 A neuron

2. Brain

The brain is encased in a bony shell and is further protected by three membranes or meninges. The inner part of these, covers the brain and is richly supplied with blood vessels. It brings oxygen and nutrition to underlying brain and protects it. The cerebrospinal fluid (CSF) lies between the inner and middle layers, which, provides cushioning and ions to the brain and spinal cord. The outer most layer is tough and fibrous and provide mechanical support.

The vertebrate brain is divided into three basic regions, the **hindbrain**, the **midbrain** and the **forebrain** (Fig. 15.2).

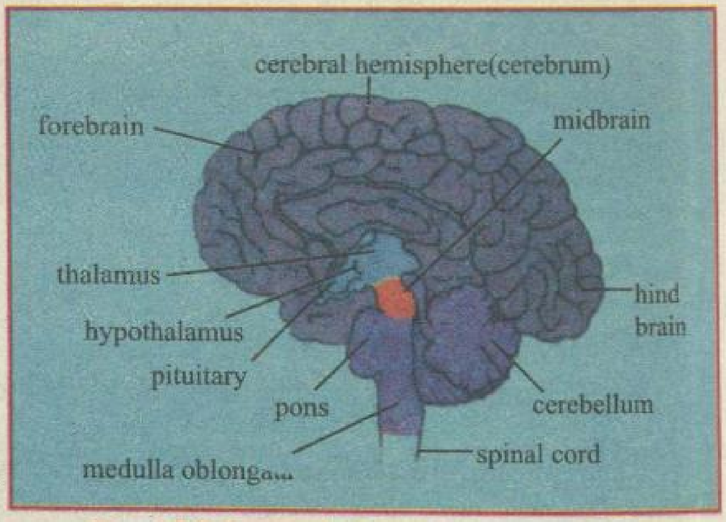

cerebral hemisphere(cerebrum)
forebrain
midbrain
thalamus
hind brain
hypothalamus
pituitary
pons
cerebellum
spinal cord
medulla oblonga...

Fig. 15.2 Lateral view of Human Brain

The hind brain is chiefly concerned with involuntary, mechanical process. It consists of three primary structures. (1) The **medulla oblongata** which lies on top of the spinal cord and contains many of the centres that control involuntary process like breathing, blood pressure and heart beat. All communication between brain and spinal cord pass through the medulla. (2) The **pons** that is present on top of the medulla and contains the longitudinal bundles of myelinated fibres running between brain and spinal cord and controls balance and muscle coordination. (3) The **cerebellum** lies behind the medulla and controls balance and muscle coordination.

The human brain is like a super computer performing a variety of activities. Such as receiving information then interpretting it, passing messages and storing memory.

The midbrain lies between the hindbrain and forebrain and connects the two. It processes the visual and auditory information from the eyes and ears before sending them to the forebrain.

The forebrain is most advanced in human. Its lower most part which lies above the midbrain is called **hypothalamus** which control, heart rate, blood pressure, body temperature, hunger, thirst, sex and anger in addition to its hormonal role. Resting above the hypothalamus is the **thalamus** which provides connections between many parts of brain and between sensory system and cerebrum. It may also control mood and feelings. Sleep may be influenced by thalamus centre along with the midbrain and hindbrain. It is concerned to keep the body alert. The cerebrum is the top most and the largest part of the forebrain. It is divided into two hemispheres comprising 15 billion nerve cells. Each hemisphere is divided into four major lobes.

(i) At the back are the occipital lobes which receive and analyze visual informations.

(ii) At the lower sides of the brain are the temporal lobe which are primarily concerned with hearing.

(iii) At the front of the brain are the frontal lobes which regulate fine motor control including movements involved in speech.

(iv) Above the temporal lobe and behind the frontal lobe are the parietal lobes which receive stimuli from the skin and also provide awareness of the body position. Memory track are also supposed to be present in the cerebrum.

Spinal cord

Spinal cord is a thick dorsal neural track extending from the brainstem to the lower back. It is completely enclosed by the vertebrae of the vertebral column just as the brain is enclosed by the bones of the skull. Most of the spinal cord consists of ascending track conducting sensory impulse towards the brain and descending track carrying impulses down ward to motor neurons with in the spinal cord. At every level the spinal cord also serves as a reflex center possibly involving a variable numbers of inter neurons. There are 31 pairs of spinal nerves arising from the spinal cord. Spinal cord is concerned with spinal reflex actions and also serves as pathway of information from and to the brain.

15.2.2 Peripheral nervous system

When we look at the entire nervous system in our body, we can clearly make out its two big divisions. One part consists of nerves ramifying all the parts of the body. This constitutes the peripheral nervous system. The other part consists of brain and spinal cord which form the central nervous system.

The peripheral nervous system consists of three systems of nerves,

1. Cranial and Spinal nerves 2. The sympathetic nerves 3. Parasympathetic nerves

The latter two systems together constitute the **autonomic nervous system**. The former is known as the cranial ans spinal system of nerves.

The cranial nerves travel between the brain and the various organs without passing through the spinal cord. The cranial nerves are sensory, motor or mixed nerves. These nerves are associated with responses involving involuntary action.

The autonomic nervous system comprises the **sympathetic nervous system** (SNS) and the **parasympathetic nervous system** (PNS). The former originates from cervical, thoracic and lumber region of the spinal cord while the latter extends its nerves fibers from the cranial and sacral ends of the central nervous system.

The sympathetic nervous system prepares the body for emergency situation and is responsible for responses associated with flight or fight. The heart beat is strengthened and accelerated, blood pressure and blood sugar level are increased and blood moves from vessels within trunk to those of arms and legs to support fighting or running. The parasympathetic nervous system on the other hand is involved in eating, sexual activity and urination etc. Autonomic nervous system regulates involuntary system of the body automatically.

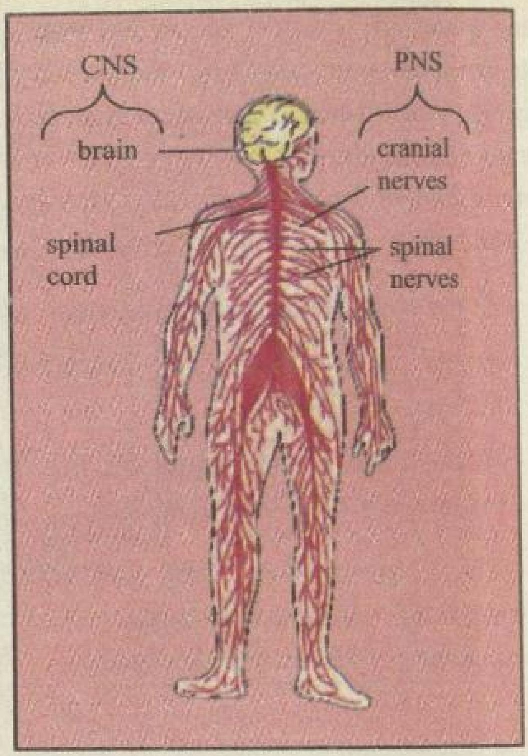

CNS
PNS
brain
cranial nerves
spinal cord
spinal nerves

Fig. 15.3 The general arrangement of the central nerves system (CNS) and peripheral nervous system (PNS)

Reflex action and Reflex arc

The neuron or nerve cell is considered the anatomical unit of the nervous system. The reflex arc is regarded as the functional unit of the system. A reflex is an unvarying and automatic response to a specific stimuli.

The most common example of reflex action is of knee-jerk reflex. If the tendon on the muscle lying just below the knee is given a sharp below the leg will extend sharply. This response is performed by creation of an impulse in sensory neurons that is carried to the spinal cord. A **synapse** with a motor neuron in the cord results in the impulses moving along an axon of the motor neuron to the exterior muscle of the leg. The contraction of the exterior muscle produces knee jerk (Another example of reflex action is the touching a hot object by chance and hand is is suddenly withdrawn.)

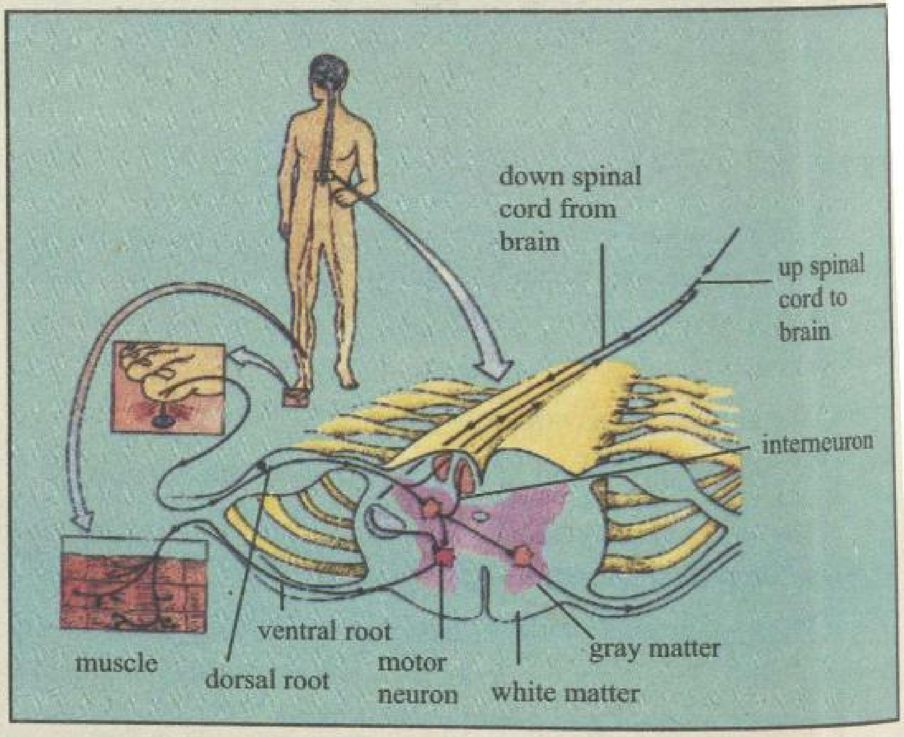

down spinal cord from brain
up spinal cord to brain
interneuron
ventral root
gray matter
muscle
dorsal root
motor neuron
white matter

Fig. 15.4 Reflex arc in reflex action

Reflexes are mechanisms for maintaining appropriate posture regulating blood pressure and orienting the body to environmental condition that threaten the organisms.

Involuntary action

A spinal nerve arises from spinal cord by two roots, a dorsal root consisting of sensory neurons and a ventral root consisting of motor neurons. The two roots combine to form a spinal nerve. The nerve thus formed is a mixed nerve. In an organ which is supplied by it i.e. fore-arm of man the sensory fibers supply the skin (a sense organ) and the motor fiber supply muscles. When a person accidentally touches something very hot the hand is abruptly withdrawn. What happens is that the sensory fibers carry the impulse to the spinal cord and from it message is transmitted to the muscles of arm to contract and the hand is withdrawn without the involvement of brain. In the spinal cord (grey matter) the associative neurons transfer the nerve impulse from sensory to the motor neurons.

An involuntary action is an action which is elicited without any conscious recognition are effort by an organism. These actions have adaptive values because these actions required to be produced at once for the survival of the individual and safe existence.

A nervous pathway which operates automatically without having to wait for directions from brain is a reflex arc. Many such reflexes operate in the body and increase the efficiency of nervous system.

Voluntary action

An action which takes place willingly under the directions from brain is a voluntary action. e.g. lifting of book, turning off an electric switch, riding a bicycle so on and so forth.

In voluntary action the sensory stimuli may be conveyed directly to the brain through sensory neurons or may first go to the spinal cord from where the information may be passed on to the brain by associative neurons. The brain then comprehends the informations and send motor impulse to the specific effectors for relevant controlled response.

15.3 Receptors in Man

Receptors are the sensory organs which receives a stimulus. Following are the main receptor organs in man.

1. Organs of sight (eyes).
2. Organs of hearing (ears)
3. Organ of smell (nose)
4. Organs of taste (taste buds on tongue)
5. Organ of touch (skin)

Sight

Eyes are the most marvellous of the sense organs as they make us aware of various objects around us, nearby and far away. When we see a tree we do not have to touch it or climb its branches in order to know what it is like. With normal vision we can reach out as far as our eyes can see and are thus become aware of events and circumstances around us. The eyes are organs of sight enabling us to appreciate shape, colour and movements of objects and persons around us.

Structure of the eye

In order to know how the eyes make us to see things we have to know how an eye is constructed. It is a relatively small organ, spherical in shape except in the front portion (the transparent region) where it bulges out a little. In the average person the eye is less than one inch (about 2.4 cm) in diameter Each eye is located in a bony socket called **orbit**. The orbit is formed partly by the bones that surround brain and partly by the bones of upper face. The sockets also contain muscles that move the eye ball, the nerves and blood vessels that supply the eye balls. In front of each eye are eye-lids, an upper and a lower, which acting together act as a curtain to shut out light. As lids separate or when the eyes open the front portion of the eye ball is exposed and light can enter. Image is formed by the light rays entering the eye through the anterior transparent portion.

An eye has the following parts.

1. Cornea 2. Iris 3. Lense
4. Sclerotic layer 5. Choroid layer
6. Retina 7. Blind spot
8. Aqueous chamber and aqueous humour
9. Vitreous chamber and vitreous humour

A camera which is a human invention is based on the same principle as the human eye.

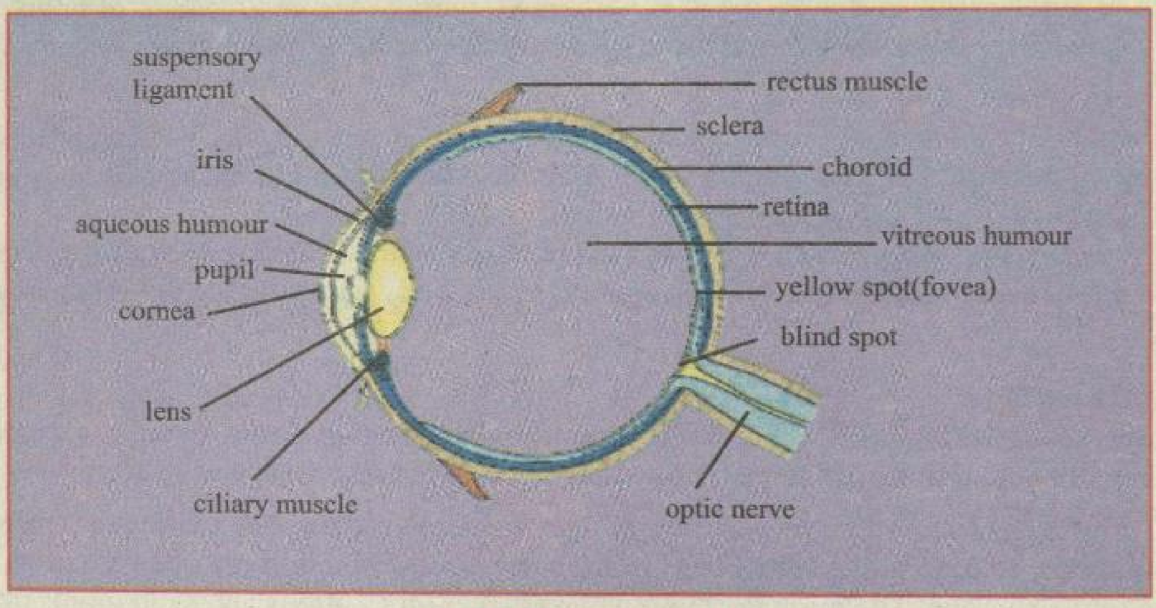


Fig. 15.5 Structure of eye

The **sclerotic** of eye ball is the out-most layer, white in colour and is thick and firm. It is transparent in front and bulges out slightly to form the **cornea**. Below sclerotic is the second layer of the eye ball called **choroid** , which is pigmented and vascular. Behind cornea the choroids bends inwards to form the **iris** having a circular opening called **pupil** through which the size of pupil can be increased or decreased. Situated behind pupil is a biconvex **lens**, which undergoes changes in convexity during the process of focusing. It is kept in place by suspensory ligaments and muscles.

The third and the inner most layer of eye is the **retina**. It is the sensitive layer of the eye. It is supplied by branches of optic nerve which enters the eye ball from brain.

The sensory cells of retina are of two types:

(a) Rods (b) Cones

These cells help in the formation of image on retina. The cones enable to differentiate colors while the rods are sensitive to white light. Above the point of entry of optic nerve is a **blind spot**.

Animals like cat can see in almost dark as it has additional rods but cannot differentiate colours because cones are absent from its retina.

The **iris** divides the cavity of eye into an anterior aqueous chamber containing a fluid the **aqueous humour** and a large posterior chamber, the **vitreous chamber**, this contains transparent jelly like vitreous humour. The **pupil** (opening in the iris), the lens behind the iris, the aqueous humour and the vitreous humour are all involved in the focusing of a clear and sharp image on retina.

Study the model of human eye and a fresh eye of a sheep / goat.

There are six muscles present in the orbit attached to the outer side of sclerotic layer that cause the movements of the eye in different directions. Also present in the sockets are the tear glands, the secretion of which washes the eyes.

Image Formation

During focusing, the light rays coming from object pass through cornea and lens. The light rays reflected from a given point at a distance striking the cornea are almost parallel to each other. These rays are focused by the lens on the retina on a special spot called **fovea centralis** (yellow spot) for producing sharp image.

The lens plays its role by changing its convexity to produce enough refraction in addition to that produced by cornea to bring the image into focus and form a clear image on retina.

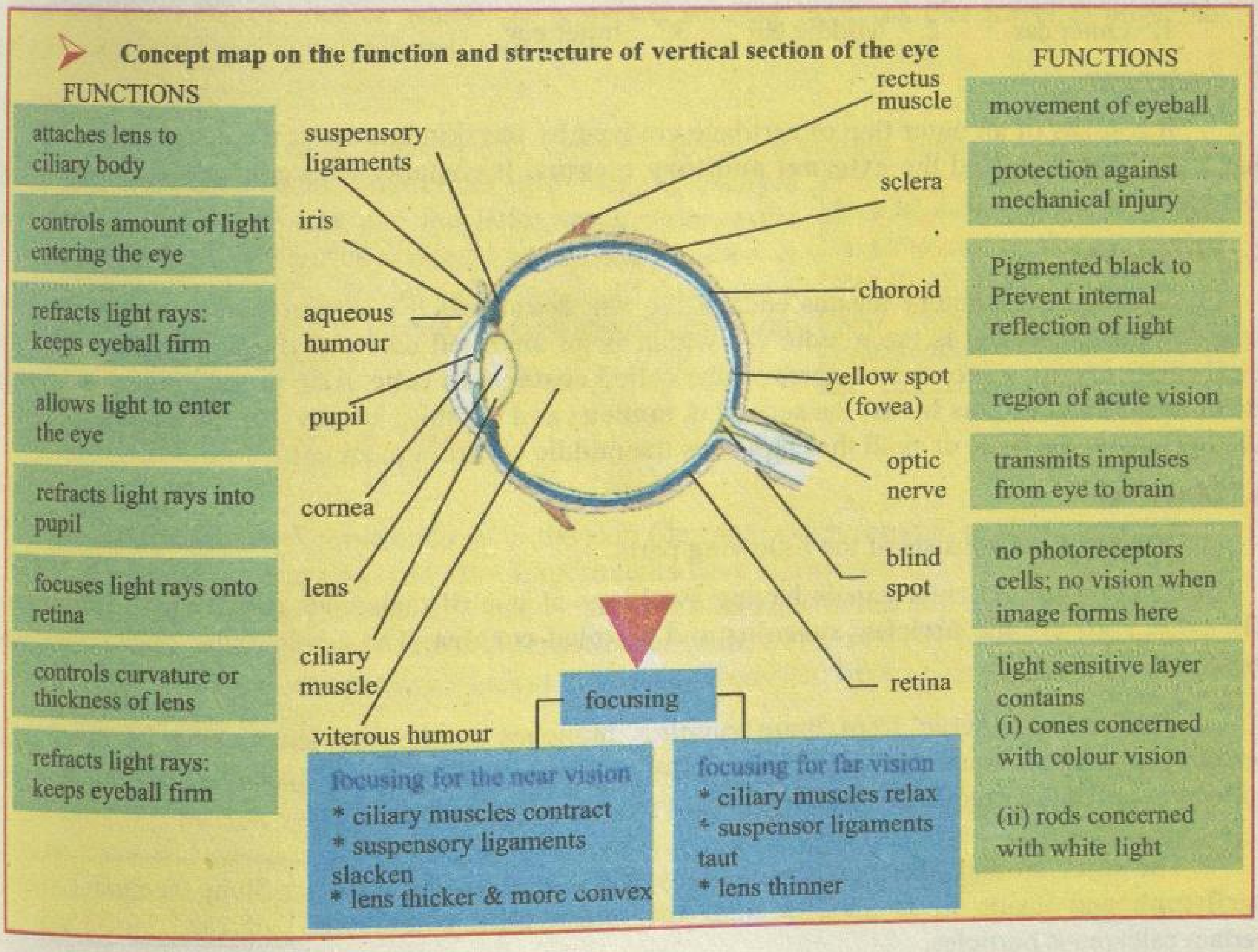
Far sighted and near sighted vision

Far sightedness

In far or long sightedness the image is formed behind the retina. The cornea and the lens cannot bend the light rays enough to focus on the retina. Artificial lenses are used that bend the incoming light rays before they reach cornea thus aiding the cornea and lenses to focus the image on retina.

Near sightedness

In the near or short sightedness (myopia), the lens and cornea focus the image of a distant object at a point in front of the retina. This problem is corrected by a concave lens which is thinner in the center than at the edges.



Concept map on the function and structure of vertical section of the eye

FUNCTIONS
attaches lens to ciliary body
controls amount of light entering the eye
refracts light rays: keeps eyeball firm
allows light to enter the eye
refracts light rays into pupil
focuses light rays onto retina
controls curvature or thickness of lens
refracts light rays: keeps eyeball firm
suspensory ligaments
iris
aqueous humour
pupil
cornea
lens
ciliary muscle
viterous humour
rectus muscle
sclera
choroid
yellow spot (fovea)
optic nerve
blind spot
retina
focusing
focusing for the near vision
* ciliary muscles contract
* suspensory ligaments slacken
* lens thicker & more convex
focusing for far vision
* ciliary muscles relax
* suspensor ligaments taut
* lens thinner
FUNCTIONS
movement of eyeball
protection against mechanical injury
Pigmented black to Prevent internal reflection of light
region of acute vision
transmits impulses from eye to brain
no photoreceptors cells; no vision when image forms here
light sensitive layer contains
(i) cones concerned with colour vision
(ii) rods concerned with white light

Colorblindness

As already mentioned there are two kinds of light receptor cells in the retina, the rods and the cones. These are the cones that enable us to distinguish colours. There are three kinds of cone cells adapted to receive three primary colours i.e. blue, green and red. To receive other colours the eye requires coordinated activation of the three kinds of its cone cells. In a colorblind person one type of cone cells are lacking. Such a person is unable to distinguish between green and red colors and is called colorblind. Colorblindness is a genetic (hereditary) defect (Fig. 15.6), discussed in detail in chapter 17.

There are certain other defects of human eye such as night blindenss in which a person is unable to see after sun-set; and cataract which is the defect of aqueous humour.

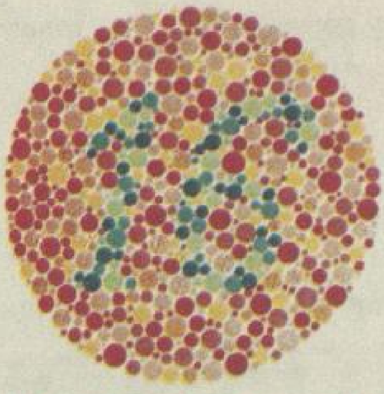


Fig 15.6 Color blindness chart

Organ of hearing (ear)

Hearing and balancing

The ears contain receptor cells that are sensitive to sound vibrations between frequencies of 20 Hz to 25000 Hz (hertz). The exact range varies with age of a person.

The human ear has the following divisions.

1. Outer ear 2. Middle ear 3. Inner ear

1. Outer ear

It consists of an outer flap of cartilage covered by the skin known as the ear **pinna** and a tube that leads inwards called the **external auditory meatus**. It contains sebaceous glands that produce secretions.

2. Middle ear

The external auditory meatus ends at the **ear drum** which is a membranous structure. From here onwards (inwards) is the middle ear which is an air filled cavity and communicates with the nasal cavity (cavity of nose) by a narrow tube called **eustachian tube**. Also present in the middle ear are three bones known as **incus**, the second is **malleus** and the third **stapes** that fits into the window-like opening in the bone of skull that separates the middle ear from inner ear.

3. Inner ear

The inner ear consists of the following parts.

There are 3-semicircular canals having swellings at one of their ends called the **ampullae**. The other parts are the **utricles**, **succulus** and a coiled **cochlea**. The semicircular canals open into these parts.

The auditory nerve from brain supplies branches to the cochlea making its inner cells sensitive to sound vibrations. The three semicircular canal, utricles, succulus and cochlea are collective called the **membranous labyrinth.**

The space around the membranous labyrinth contains a fluid, the **perilymph** and inside it, is another fluid the **endolymph** containing certain calcareous particles.

Study the model of ear

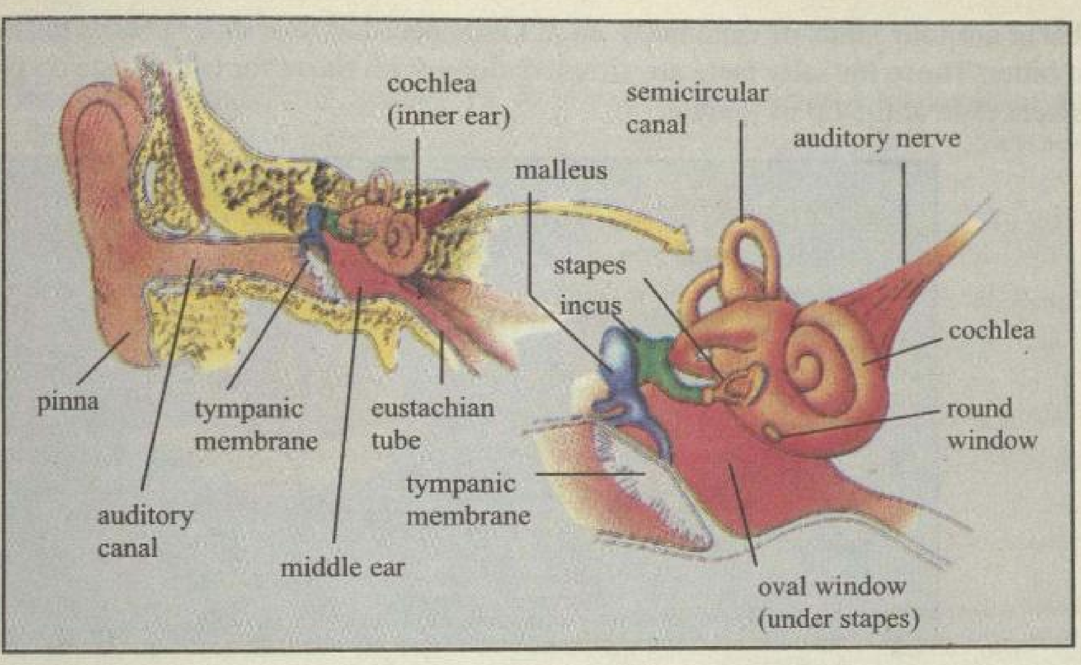


Fig. 15.7 Human ear

Hearing

The sound vibrations in the air are directed into the external auditory meatus. These strike the ear drum and make it vibrate. The ear drum transfers the vibrations to the three ossicles and through these to the perilymph and the endolymph which are set into motion. The particles in the endolymph strike the sensitive cells of cochlea which are activated sending impulses that travel through the auditory nerve to brain and are interpreted as sound.

Balancing

The 3-semicircular canals, utricles and sacculus are the structures that are concerned with maintaining balance and posture. The former responsing to changes in the directions and movement and the latter to changes in the posture. Any defect in these causes dizziness and loss of balance. It is common experience that if a person goes round and round on a swing, he loses his balance and is unable to stand upright for some time until the balance is restored.

One of the causes of deafness is puncture in the ear drum due to an injury or infection, thus imparing the drum vibrations.

Other senses: Touch, Taste and Smell

Touch

There are encapsulated nerve endings in the skin (dermis) which respond to slight pressure on skin. The skin responds to heat and cold also. Experiments have shown that the spots in the skin that respond to cold do not respond to heat and vice versa. It is also known that any stimulus that effects the free and exposed nerve endings produce sensation of pain. Some sensory receptors are placed deeper in the tissues and are not stimulated unless the tissues above are firmly compressed.

Taste

It is generally believed that the entire tongue is the organ of taste but it is not so. The tiny organs of taste are located on the surface of tongue. These are called the **taste buds.** They are spherical in shape and microscopic in size. A taste bud consists of a group of cells that are supplied with nerve endings from the nerve that penetrates the inner part of the mouth cavity.

There are four kinds of taste buds, each kind specified to seek a specific taste i.e. sweet, salty sour, and bitter. Those for salty taste are situated along with those for bitter taste on the side of tongue and for sweet taste at the tip of tongue.

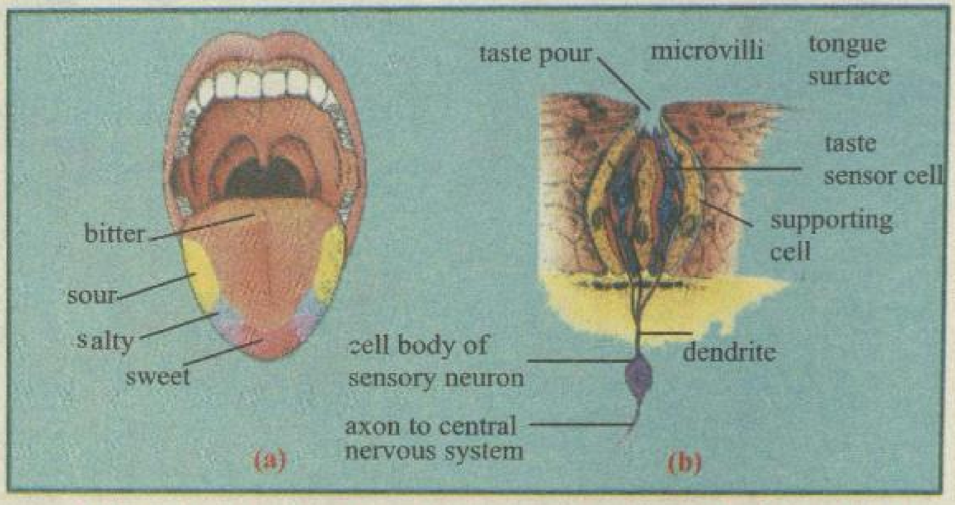

bitter
sour
salty
sweet
(a)
taste pour
microvilli
tongue surface
taste sensor cell
supporting cell
cell body of sensory neuron
dendrite
axon to central nervous system
(b)

Fig.15.8 (a) taste map (b) the structure of a taste bud.

Smell

The organ of smell lies in the nasal cavity above mouth. It is also called the olfactory organ and its sensitive cells are supplied by the branches of the olfactory nerve from brain. The incoming air currents carry the smell particles of substances into the nasal cavity which arouse the sensitive cells in the organ of smell. The olfactory nerve carries the sensation to the brain, which determines the nature of a substance emitting the smell.

15.4 Endocrine System

The glands in the human body are of two types:

1. Exocrine glands
2. Endocrine glands

The exocrine glands produce fluid secretions that are delivered by tubes or ducts either to the body surface e.g. glands of skin or to the inner regions where these are required e.g. pancreas delivers its pancreatic juice to the intestine for digesting food etc.

Endocrine glands produce secretions called **hormones** that are not carried by ducts but are passed into the blood stream and carried to the target area by blood circulation. The following endocrine glands are present in the human body (Fig 15.9).

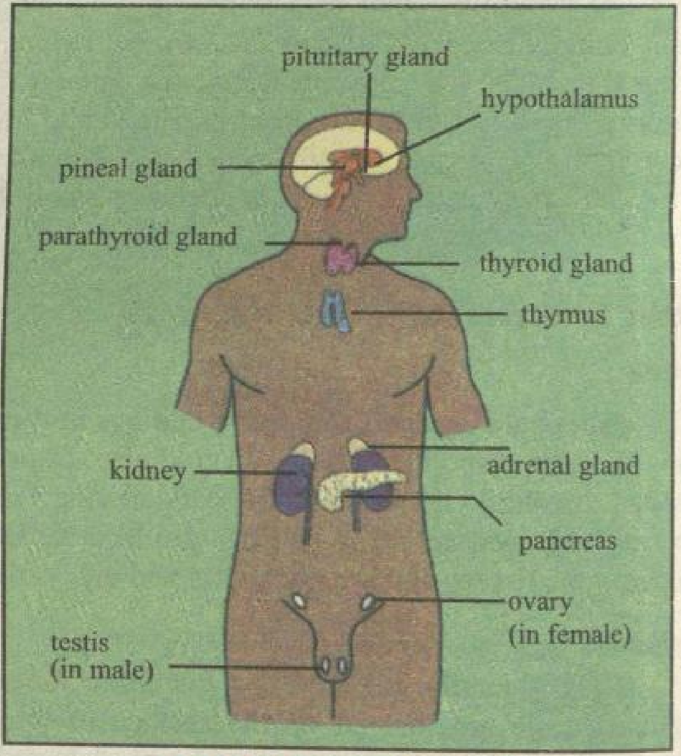

pituitary gland
hypothalamus
pineal gland
parathyroid gland
thyroid gland
thymus
kidney
adrenal gland
pancreas
ovary (in female)
testis (in male)

Fig 15.9 Endocrine glands

1. Pituitary gland
2. Thyroid gland
3. Parathyroid glands
4. Pancreas (Islets of Langerhans)
5. Adrenal glands
6. Gonads

3. Parathyroid glands 6. Gonads

The function of endocrine glands is very much inter-related. Several of the hormones produced by them serve only to alter the functions of other endocrine glands. They serve as double check automatic control over one another.

1. Pituitary gland

The pituitary gland is known as the master gland in the body and plays an important role in several ways. It has certain hormones which have direct action on the body e.g. the growth hormone.

In addition it has hormones which control the action of the other endocrine glands. It is closely associated with the base of brain in the skull. In size it is a little larger than a garden pea. There are two lobes of pituitary gland each produces its own hormones.

1. Anterior Lobe 2. Posterior Lobe

Anterior lobe produces many hormones. One of the important hormones produced by the pituitary is **somatotrophic (STH)** which is the growth promoting hormone due to which the process of growth takes place in the body. It influences all those organs and tissues of the body concerned in the process of growth.

Another important hormone is **thyroid stimulating hormone(TSH)** which stimulates the thyroid to produce its hormone. The remaining hormones of the anterior lobe of pituitary influence the activities of reproductive organs both in men and women but in different ways and controls the working of adrenal glands.

Two hormones are produced by the posterior lobe of pituitary gland. One hormone helps to conserve water in the body according to requirement, and the other has no effect on males but has certain effect in females.

2. Thyroid gland

The thyroid gland is located in the neck and fits closely around the from and side of trachea (wind pipe) just below the organ of voice of larynx. The thyroid receives a lot of blood supply to nourish its cells and to carry away the hormones it produces. It produces two hormones.

1. Thyroxin 2. Calcitonin.

The above hormones of thyroid are produced under the influence of TSH from the pituitary gland. The thyroid hormones increase the consumption of oxygen by the body tissues. This increases the rate of metabolism. They also increase the ability of a person to think. Adequate supply of these hormones is also needed for normal growth and skeletal development in children.

Goiter (abnormal enlargement of thyroid) is due to its malfunction. The major cause of this disease is iodine deficiency in the food / body.

3. Parathyroid gland

These are very small structures usually four in number embedded in the back side of the thyroid gland. They produce parathyroid hormone which control the amount of calcium and phosphate in the blood serum.

4. Pancreas

Pancreas is present in the abdominal cavity close to the stomach. Pancreas is known as double gland as it has two kinds of glandular tissues. One exocrine and the other endocrine in function. The main bulk of pancreas is **exocrine** that produces pancreatic juice which helps in the digestion and is carried by the pancreatic duct to the intestine. Distributed at various places in its tissue are groups of cells, known as **islets of Langerhans** which are **endocrine** (not having ducts). The islets of Langerhans produce two hormone:

1. Insulin
2. Glucagon

These two hormones have opposite effect in regulating use of glucose in the body. The two hormones therefore counter balance each other. When the amount of glucose in the blood plasma increases the production of insulin is also increased due to which the entry of glucose into muscles and other tissue from blood is made easier. In the absence of insulin the glucose level in the blood is raised resulting in the disease known as **diabetes mellitus.** (diabetes = to go through; mellitus = honey)

Another form of diabetes is diabetes insipidness in which there is excessive flow of urine.

Too much insulin in the blood may cause lowering of glucose level to such an extent that it may result in unconsciousness and death. Glucagon, the second hormone in such emergency situations brings about release of stored blood sugar so as to maintain a proper level of glucose in the blood.

5. Adrenal glands

Adrenal glands are paired and lie in abdominal cavity above the kidneys. Adrenal glands produce **adrenaline** which prepares the body for action in an emergency by raising blood pressure, increasing heart and breathing rate.

6. Gonads

Male gonads or Testes

They have two functions, to produce male sex-cells (sperms) and to produce the male hormones **androgens** e.g. testosterone. These are produced by the interstitial cells of testes. **Testosterone** helps in the development of male secondary sex characters such as growth of hair on the face and thickness or coarseness of voice in males.

Female gonads or Ovaries

Ovaries in female produce **oestrogen** which controls development of secondary sexual characters (development of breast etc) and causes the lining of uterus to thicken.

Drugs and Nervous System

There are different types of drugs known to us. Many of them have medicinal value and are being used by the pharmaceutical industry. But the misuse or abuse can produce serious physiological , behavioral and mental problems in a person. A brief description of some of the common drugs and alcohol are given below:

- Excessive or harmful use of drug is considered drug abuse or substance abuse. Drug abuse is a major problem. It affects people, their families and many other people with whom they interact.
- Most drugs have devastating effect on brain and other part of nervous system and may cause loss of memory and weakening of nerves due to which permanent damage to the coordination mechanism takes place.

Aspirin

It will not be an exaggeration to call it a wonder drug as it has wide ranging effects e.g. it is used as an analgesic (pain-killer), as antipyretic (anti-fever) as anti-inflammatory and is also useful in heart patients as antithrombotic, but its overuse may lead to blood thinning leading to hemorrhage with serious consequences. It is derived from opium.

Morphine

Primarily a pain relieving drug but its abuse affects the central nervous system and is addictive. It can cause constipation and lowering of blood pressure. Since the drug reduces anxiety the user of the drug develops escapist tendencies and gradually loses the confidence to face the realities of life. It can also produce serious allergic reactions, nausea and vomiting.

Heroin

It is the most addictive drug and is produced from morphine by modification in its chemical structure and this has some adverse effects as of morphine. It affects the nervous system adversely and its indiscriminate use can produce drug induced toxicity. Its addiction is extremely difficult to treat.

Cocain

It affects the mental functioning and behavior of a person causing anxiety, insomnia irritability and can make the user psychotic. It has been called as the third scrouge of humanity alcohol and heroin.

Marijuana

It is the oldest drug. It is also called charus and hashish. This drug can produce lightened sensation and hallucination. Its high doze results in death. It alters the production of hormones e.g. reproductive hormones, decreasing the production of sperms in man and ovulation in woman. Men may develop fatty enlargement of the breast.

Nicotine

Cigarette smoke contains over 1000 drugs, a large number of which are carcinogenic. The primary among them is nicotine. This drug is least sedative but highly addictive. When taken for the first time, it may cause nausea, vomiting, headache and general weakness. If a pregnant woman smokes, the nicotine damages the placenta, increasing the likelihood of miscarriages, premature births, and damage to the foetus.

Alcohol (Ethyl)

Among the most harmful of drugs, particularly in view of the frequency of its use, is alcohol. It is a central nervous system depressant. It causes temporary loss of body coordination. It is one of the causes of brain, liver and muscle tissue (including heart) damage. Alcohol in the gut also destroys certain vitamins and interferes with absorption of others leading to severe vitamin deficiencies. It is also associated with an increased risk for cancer. It produce permanent mental and physical birth defects called **foetal alcohol syndrome,** in children born to alcoholic mothers.

- In addition to addiction, the use of psychoactive drugs can impair the health of individual drug users in other ways. It can also affect their gametes, and thus the development of their children.
- The use of alcohol causes stomach ulcers and permanent damage to heart and liver.

Nervous disorders

Paralysis

It is the partial or complete loss of the power of motion or sensation especially of voluntary motions in some parts or all of the body. This is usually because of a brain stroke in which some part of the brain becomes inactive because of hemorrhage or clotting of a blood vessel in the brain, there by blocking the blood supply to the brain part. It may also be due to some viral toxins as in polio.

Neurosis

A functional mental disorder characterized by combination of anxiety, obsession, phobia depression etc.

Chemical control in Plants

As mentioned before the plants respond to various stimuli but their movements as response to stimuli are slow and limited e.g. Plants respond to light, gravity, water and chemical stimuli. The chemical substances known as plant hormones are produced within their bodies which bring about a number of responses by the plants. The plants hormones are mainly produced in the growing parts of plants such as tips of roots and shoots. There are no separate hormone producing organs in plants as compared with endocrine glands of animals. In plants hormones are mainly concerned with the growth and are therefore called **growth regulators**. In animals hormones perform a number of other functions in addition to growth. The following are important plant hormones.

1. Auxins
2. Gibberellins
3. Cytokinins
4. Abscisic acid

Auxins are involved in the change of direction of growth of shoots towards light (phototropism), against the force of gravity (negative geotropism) and growth of root toward gravity (positive geotropism). Auxins also stimulate cell elongation in stem, buds and root in certain concentration while the same hormone in light concentration will inhibit such growth.

Gibberellins were discovered by Japanese scientists in 1930s. These hormones induce rapid elongation of stem in plants. Besides this, gibberellins also help in breaking seed dormancy, induce flowering and also induce early fruiting in some plants.

Cytokinins have been found to be useful in developing tissue culture in the presence of Auxins. They also help in the germination of certain seeds, promote fruit development in certain species.

Abscisic acid is a growth inhibitor hormone and induces dormancy in seeds and buds.

KEY POINTS

1. Coordination is the way in which all the organs and systems of the body are made to work efficiently in an harmonized manner. In animals coordination is produced by two systems: nervous system and endocrine system.
2. Coordination is brought about through various elements of nervous system: receptors, sensory neurons, brain and spinal cord, motor neurons and and effectors.
3. Reflex action is an automatic nervous reaction that cannot be consciously controlled and reflex arc is the nervous pathway which carries the impulses causing a reflex action
4. Receptors are the sensory organs which receive a stimuli. Eyes, ears, nose, tongue and skin are the sense organ of the man.
5. Pituitary, thyroid, parathyriod, pancreas (islets of Langerhans), adrenal, testis (in male) and ovary (in female) are endocrine glands present in human body.
6. The abuse of many drugs e.g., aspirin, morphine, heroine, cocain, marijuana, hashish, nicotin, and alcohol can produce serious physiological, behavioral and mental problems in a person.
7. Paralysis and neurosis are the disorder of nervous system.
8. Auxins, gibberellins, cytokinins and abscisic acid are the plant hormones which areresponsible for hormonious growth of plants.

QUESTIONS

1. Fill in the blanks.

(i) The space or gap between two neurons is called.__________.

(ii) The central nervous system consists of the ________ and ________.

(iii) The three bones of the middle ear are collectively known as ________.

(iv) The external ear consists of ear pinna and ________.

(v) The eye is supplied by the sensory nerve called ________.

(vi) Pancreas produces the pancreatic juice and also hormones called ________ and ________.

2. Write whether the statement is "true" or "false" and correct the statement if it is false.

(i) Living lants and animals both possess nervous system.
(ii) Muscle and glands are called effectors.
(iii) The nerves that arise from brain supply sense organs (receptors).
(iv) Drugs cause damage to vital organs of the body.
(v) Short sighted person cannot clearly see distant objects.

3. Each question is followed by four options. Encircle the correct answer.

(i) The neurons in the central nervous system are:

(a) motor neurons (b) sensory neurons, (c) associative neurons (d) all of the above

(ii) The sensitive layer of the eye is:

(a) choroids (b) sclerotic (c) retina (d) cornea

(iii) The name membranous labyrinth is given to the:

(a) outer ear (b) middle ear (c) inner ear (d) none of the above

(iv) The largest part of human brain with hearing is:

(a) fore-brain (b) mid-brain (c) hind-brain (d) all of the above

(v) The main part of ear concerned with hearing is:

(a) semicircular canals (b) eardrum (c) membranous labyrinth (d) pinna

4. Describe the central nervous system in man.

5. Write an account of the structure and function of human eye.

6. Write what you know about the human ear. Which part is the actual part concerned with hearing?

7. Write an essay on the chemical control in plants.

8. Name the various endocrine glands of man and give detail of hormones produced by the pituitary gland.

9. Write notes on the following.

(i) Reflex action

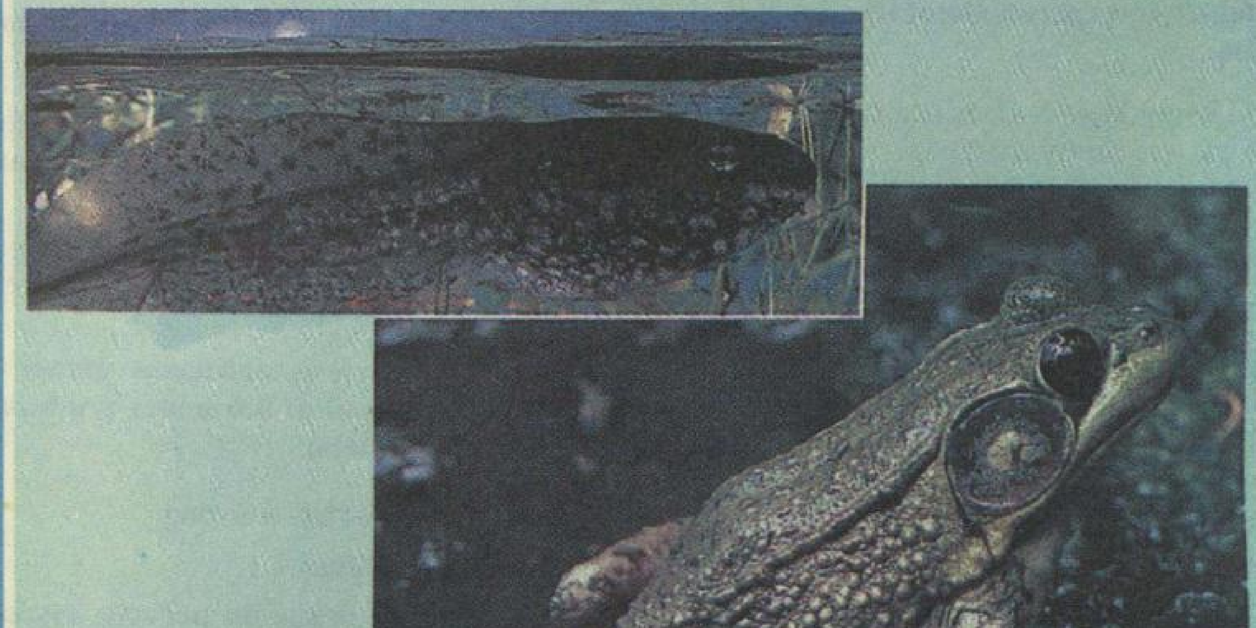
(ii) Effects of drugs on nervous system

(iii) Nervous disorders

(iv) Structure of neuron

Section
5

Development of Organism and Continuity

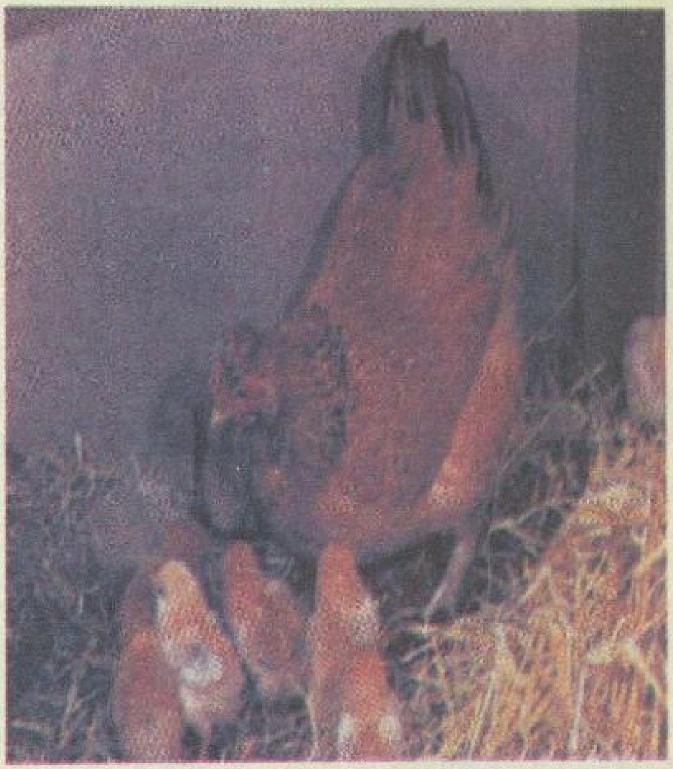


16

REPRODUCTION

IN THIS CHAPTER YOU WILL LEARN:

- Definition of reproduction its main types, and differences between asexual and sexual reproduction
- Different types of asexual reproduction in plants & animals
- Advantages and disadvantages of vegetative propagation
- Sexual reproduction in plants and animals
- Definition of pollination, its types and significance
- Life cycle of a flowering plant and process of double fertilization
- The formation and dispersal of seeds and fruits, structure of seed and its germination
- Fertilization and stages of development in frog



Introduction

One of the basic characteristics of living things is their ability to reproduce. Reproduction is a biological process by which living things produce their young ones which are similar to the parents. Reproduction ensures the continuity of a species and also helps the organism to adapt itself to the changing environment.

16.1 Types of Reproduction

There are two principal types of reproduction, asexual and sexual. The organisms produced through asexual reproduction are genetically identical among themselves and also to their parents. These organisms fail to cope with the changing environment and if continue to reproduce this way, ultimately become extinct. Asexual reproduction is advantageous for the organisms as this method is efficient, a shorter time is taken for the species to inhabit or colonize the habitats. In the long term the organisms must reproduce by sexual reproduction to become successful over longer periods of time.

A population of genetically identical individuals produced from a single parent is called a clone

In asexual reproduction no gametes are involved, all the offsprings are produced from single parent by mitotic cell division.

The most important difference between asexual and sexual reproduction is that in the former, there is no mixing of hereditary material prior to the formation of new organism, but in the latter there is always mixing of hereditary material, either between two cells of the same organism or between two cells of different organisms of the same species.

The non mixing of hereditary material in asexual reproduction does not improve the genetic make up and does not produce variety among the descendents. So if environmental conditions, to which these organisms are well adapted, are changed, this would affect all the members of that species. Suppose if asexually produced plant have no resistance to a particular disease the whole population could be wiped off. In contrast the genetic variability is produced by sexual reproduction, which results in most cases by meiosis and mixing of hereditary material. This genetic variability helps the organisms to live successfully in changing environment. So some of the offspring would survive, even if most of them are wiped off by a particular disease, because the surviving organisms have the resistance to that disease. Some of the common methods of reproduction in plants and animals are binary fission, multiple fission, budding, spore formation, vegetative propagation, regeneration, parthenogenesis and sexual reproduction.

16.1.1 Asexual reproduction

Asexual means without sex and this method does not involve the fusion of gametes in most cases. There are many different forms of asexual reproduction employed by different kinds of organisms including plants. Some of these methods are:

(i) Binary fission in bacteria

It is a type of asexual reproduction in which one unicellular organism divides into two by simple division(Fig 16.1). Bacteria belong to kingdom monera and exhibit binary fission. Under favourable conditions one bacterium would divide into two bacteria after about every 20 minutes. They have a single circular chromosome made of DNA. Steps involved in binary fission are: (1) When the DNA molecule replicates, it results in the formation of two chromosomes. (2) These two chromosomes move towards opposite sides. (3) The middle portion of the cell membrane invaginates inwards from the two sides and when meet in the centre it separates the two halves of the bacterial cell. (4) New cell wall is deposited between two cross cell membranes. (5) The daughter bacteria grow to their normal size, and then separate from one another.

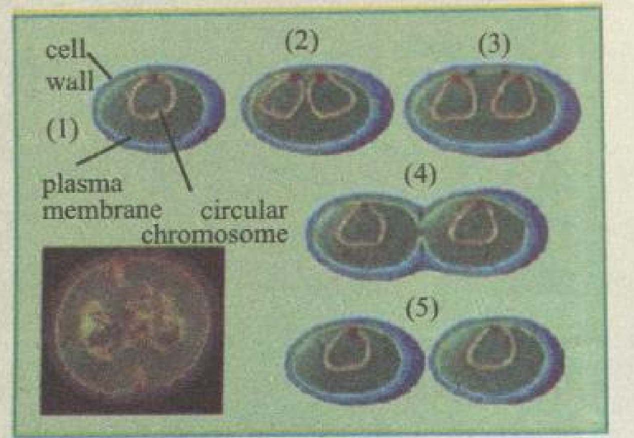


Fig. 16.1. Binary fission in a bacterium

(ii) Budding in yeasts

Yeast, a fungus, consists of a single microscopic spherical cell. The cells of yeast reproduce by budding. It is a special type of asexual reproduction, in which a small bud or out-growth is formed on one side of cell. The nucleus divides by mitosis into two nuclei, and one of the two nuclei is passed on to the bud. Bud enlarges and is finally cut off as an independent cell. When the process of budding is rapid, the individual cells so formed, do not separate at once and as a result, small groups of attached cells may some times be seen.

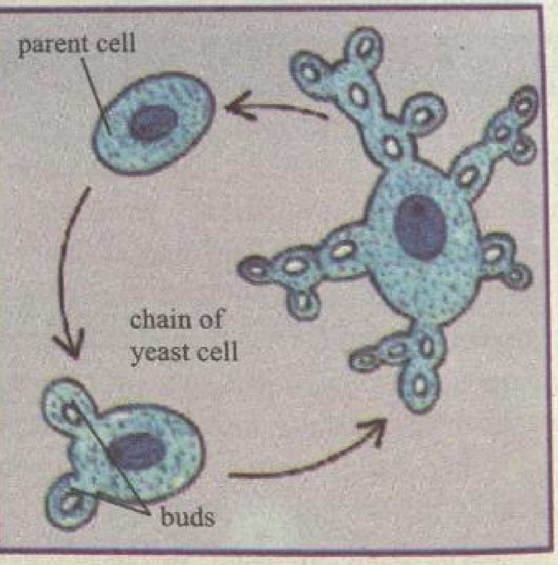


Fig16.2 Budding in yeast

Practical Work: Observation of budding in yeast using prepared slides.

1. How many buds are present on a single yeast cell?
2. Can you find nucleus in any bud?

(iii) Spore formation in *Rhizopus*

You have already studied the structure of *Rhizopus*. Asexual reproduction in *Rhizopus* is by the formation of spores in sporangia which are borne on the tips of sporangiophores. Spores are single celled, thick walled, and are produced in sporangium without sexual process. These spores are released from the sporangium and are carried by wind. Each spore when exposed to suitable conditions forms new *Rhizopus* mycelium.

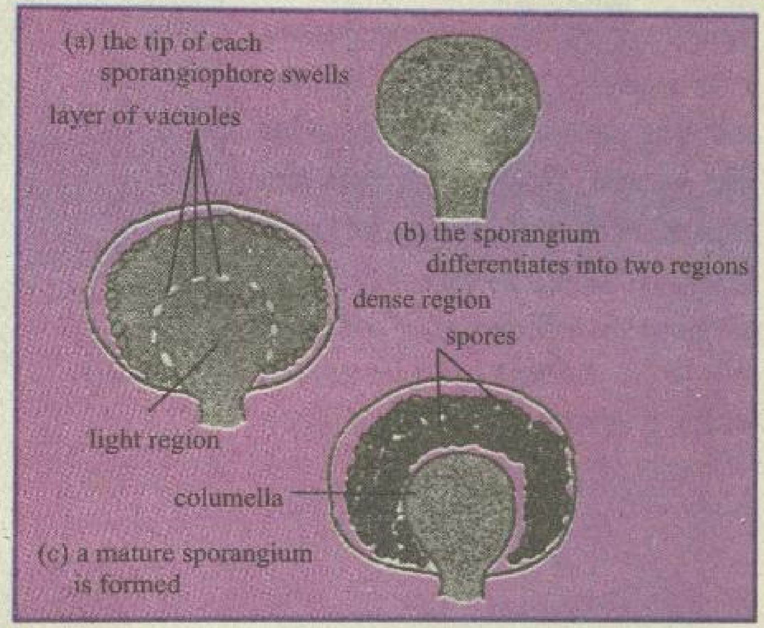

(a) the tip of each sporangiophore swells
layer of vacuoles
(b) the sporangium differentiates into two regions
dense region
spores
light region
columella
(c) a mature sporangium is formed

Fig. 16.3 Sporangium and spore formation in *Rhizopus*

Practical Work Examination of sporangia and spores of Rhizopus, from prepared slides and fresh material

Study the prepared slides of *Rhizopus* showing sporangia and spores under the microscope.

In chapter 5, you have already learned to prepare slide of *Rhizopus* from fresh material. Make a slide and study it under microscope.

Draw labeled diagrams of sporangia and spores.

1. What is the shape of sporangium?
2. What is the shape of spores?
3. How many spores are present within a sporangium?

16.1.2 Vegetative propagation in flowering plants

It is a process of asexual reproduction, which involves the vegetative parts of a flowering plant such as stem, leaves etc.

Following are different types of vegetative propagation in flowering plants.

(a) By stem (b) By leaves

(a) By stem

Common methods of vegetative propagation by stem are by runners and suckers.

Runners: Some stems from which new offspring can be produced are runners. A runner is a long, thin, stem which is spread along the surface of soil. It gives adventitious roots at nodes, which grow into the soil. The nodes may separate giving rise to new plants. Examples are grasses, strawberry etc (Fig 16.4).

Suckers: These are lateral branches of the stem with terminal buds and grow from the base of under ground stems of certain plants. They grow obliquely to the soil level and produce new aerial shoots with adventitious roots, establishing new daughter plant. Examples are mint (*podina*) and banana. (Fig 16.4)

(b) By leaf

In some plants like Bryophyllum, vegetative propagation is by leaf. The leaves of this plant have notches on their margins with adventitious buds. When a leaf falls on the ground the adventitious buds grow into new plants. (Fig. 16.5)

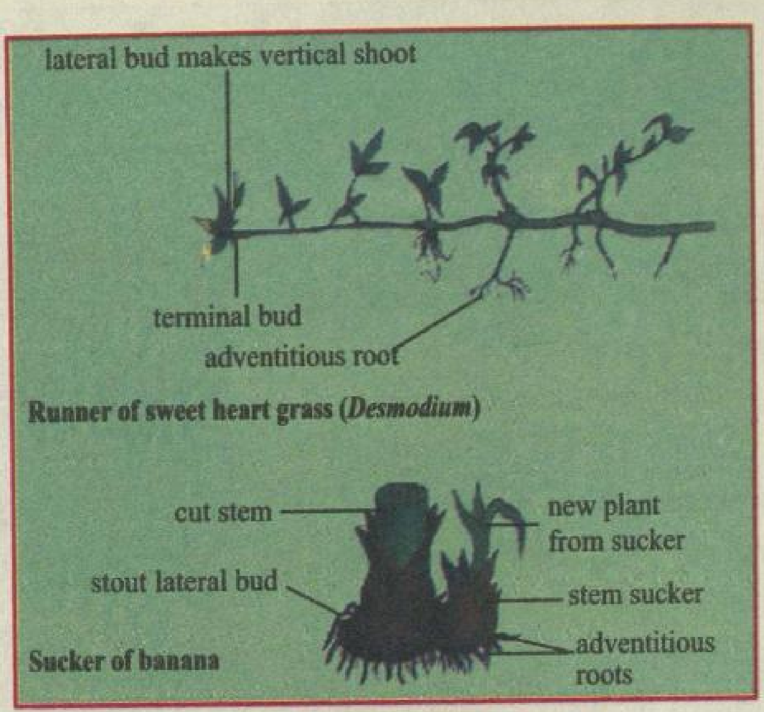


Fig. 16.4 Runner and Sucker

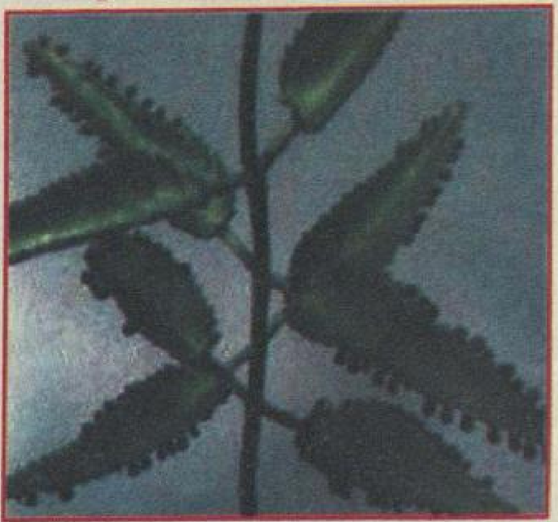


Fig.16.5 Leaves of bryophyllum showing adventitious buds in the notches.

16.1.3 Artificial vegetative propagation

Some plants can be artificially propagated by using their vegetative parts and this is called artificial vegetative propagation. Following are a few types of artificial vegetative propagation by stem, in plants.

1. Cuttings

These are short pieces of stem with 2 or 3 nodes and buds, which are cut obliquely below a node from a plant. The cuttings are embedded in soil bed with at least one node. The adventitious roots and shoots grow from buds of the portion below the soil and above the soil respectively, forming a new plant, e.g. sugar cane, balsam, sweet potato, Hibiscus and rose. In Rasberry and black berries, root cuttings are also used for artificial vegetative propagation. [Fig. 16.6 (A)]

2. Grafting

This is a technique whereby a branch from a desired variety of plant is joined to another plant with well established root system. The plant from which the branch is taken is called **scion** and the plant to which it is joined is called **stock**. The two plants involved are normally the varieties of same species e.g. oranges, lime, lemon and mango. [Fig. 16.6 (B)]

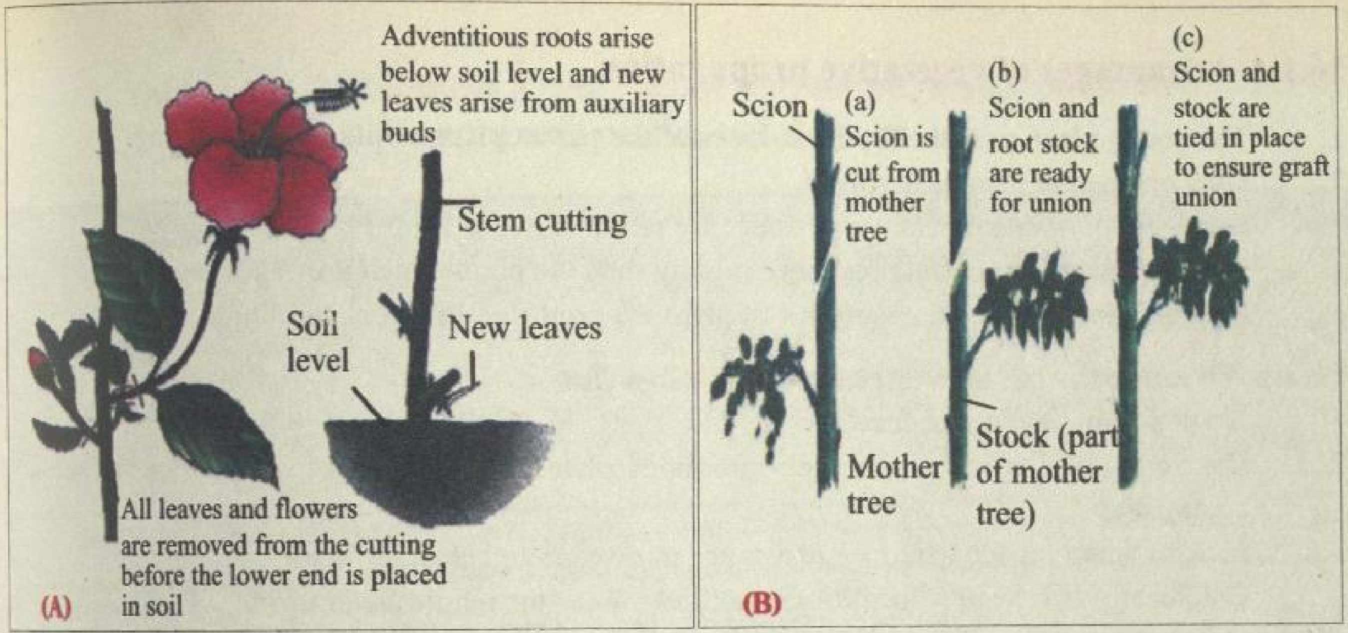

Adventitious roots arise below soil level and new leaves arise from auxiliary buds
Stem cutting
Soil level
New leaves
All leaves and flowers are removed from the cutting before the lower end is placed in soil
(A)
Scion
(a) Scion is cut from mother tree
Mother tree
(b) Scion and root stock are ready for union
Stock (part of mother tree)
(c) Scion and stock are tied in place to ensure graft union
(B)

Fig. 16.6 Artificial vegetative propagation in plants: (A) by stem cutting, (B) by stem grafting

Practical work: Study of artificial vegetative propagation by stem or leaf cuttings.

Take one stem cutting of rose plant with at least 6-8 inches in length and having 4-5 nodes with buds. Plant it obliquely in the soil in one pot. The pot should be well watered.

Take leaf cuttings of Bryophyllum leaf. Put 2 or 3 of these cuttings on the surface of soil in the other pot. The pot should be watered regularly.

Observe after a few days and answer the following questions.

1. How long does it take for the stem cutting to develop shoots from the bud?
2. How long does it take for the adventitious bud in leaf cutting to develop a shoot?

Cloning

It is also a type of asexual reproduction in which a population of genetically identical individuals are produced from a single parent using the parents tissues of vegetative cell under proper laboratory conditions.

A clone has the advantage that the good characteristics of the parent are passed as such to all the offspring. This is very useful quality of the next generation.

4. Underground stems

There are certain plants with underground stems, which also reproduce by vegetative propagation using a small piece bearing buds, like onion bulb, corm of colocacia, rhizome of ginger or canna lily and potato tuber.

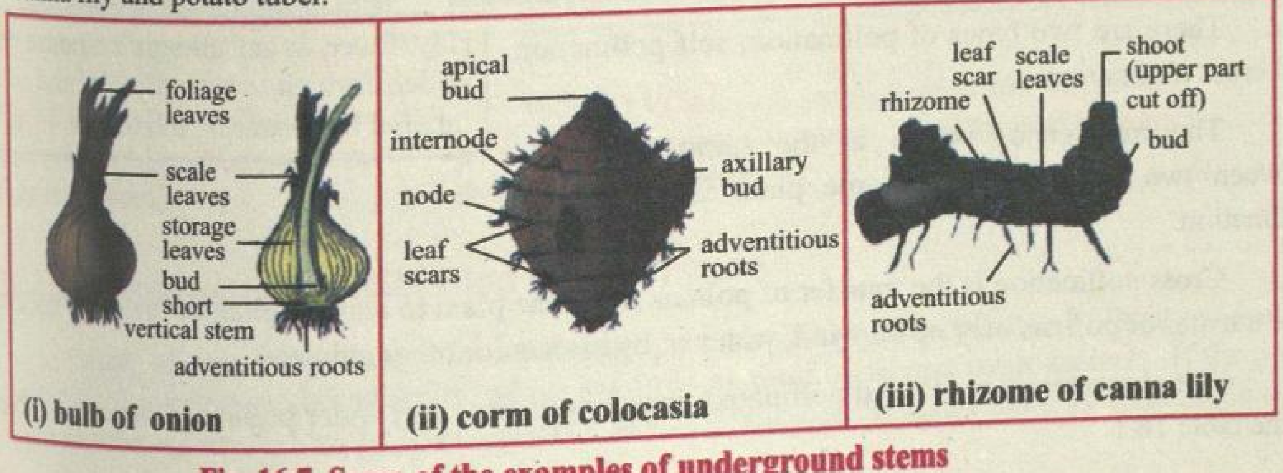

foliage leaves
scale leaves
storage leaves
bud
short vertical stem
adventitious roots
(i) bulb of onion
apical bud
internode
node
leaf scars
axillary bud
adventitious roots
(ii) corm of colocasia
leaf scar
scale leaves
rhizome
shoot (upper part cut off)
bud
adventitious roots
(iii) rhizome of canna lily

Fig. 16.7 Some of the examples of underground stems

16.1.4 Advantages of vegetative propagation

1. The young plant, uses the food resources of the parent plant, while it is developing.
2. Only one parent plant is involved.
3. Good and desirable parental characters are retained in the offspring.
4. The new plant formed matures more rapidly than the plant which grows from seeds.
5. A large number of desired varieties of plant are produced in a very short time.

16.1.5 Disadvantages of vegetative propagation

1. No new varieties are produced.
2. Over crowding of the vegetatively produced plants leads to severe competition for survival among them.
3. Lack of variety leads to reduce resistance to disease and changes in the environment.
4. Colonization of the new localities is unlikely. Thus the plants are not widely distributed.

Practical Work: Study of the following specimens: bulb, corm, rhizome and stem tuber

A bulb of onion, a corm of colocacia or arvi, rhizome of ginger or canna lily, and stem tuber of potato.

Carefully examine the external features of the above mentioned specimens. Draw labeled diagram of each specimen to show the external features and compare with the diagrams in figure16.7.

1. Which features do they have in common?
2. What are the functions of the parts of each vegetative organ?
3. What are the features which show that the specimens are underground stems and not roots?

16.2 Sexual Reproduction in Flowering Plants

The reproductive part of a flowering plant is the flower. You have already studied the structure and functions of floral parts of *Brassica* in chapter 2.

16.2.1 Pollination

The transfer of pollen grains (also called pollen) from anthers of a stamen to the stigma of a carpel of a flower is called pollination.

Types of pollination

Hay fever, is an allergic response to pollen; which are in the air, and are inhaled by us during inhalation

There are two types of pollination, self pollination and cross pollination.

The transfer of pollen in the same flower or between two flowers of the same plant is called self pollination.

Cross pollination is the transfer of pollens from one plant to another plant of the same species. The transfer of pollens may be by wind, water or by insects (or other animals).

The characteristics of wind pollinated, insect pollinated and water pollinated flowers is given in the table 16.1.

Table 16.1 Differences among wind pollinated, insect pollinated and water pollinated flowers.

Wind pollinated flowers	Insect pollinated flowers	Water pollinated flowers
1. Flowers are small and without bright coloured petals.	The flowers are large and have brightly coloured petals.	The flowers are small and without brightly coloured petals.
2. Pollens produced in enormous numbers and are light in weight.	Pollens are not produced in enormous numbers and are sticky.	The pollen grains neither sink or float on the surface of water, due to their peculiar specific gravity. They float under water.
3. The flowers have long feathery stigmas.	The stigmas are variously shaped so that pollen grains are attached or entangled there.	The flowers have long stalks. The styles are long and the stigmas are sticky.
4. The filaments of stamens are long and have **versatile** anthers.	Stamens have short filaments and anthers are not versatile.	Stamens have short filaments and anthers are not versatile.
5. The flowers do not produce nectar.	The flowers produce nectar by glands called **nectaries.**	Do not produce nectar.
6. Examples are the flowers of maize, wheat and rice.	Examples are the flowers of most dicots e.g. Bougainvillea, rose and calotropis.	Examples are the flowers of plants such as Potamogeton and Vallisneria.

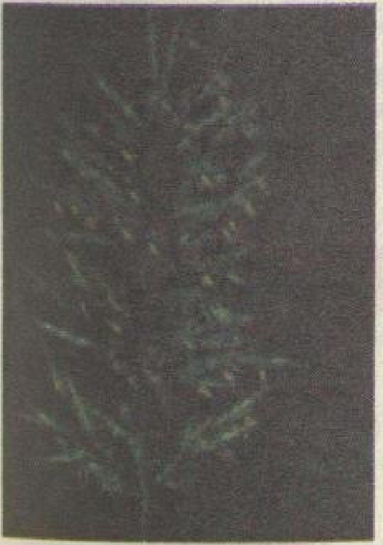


Fig 16.8(a) Wind pollinated flowers with exposed anthers (grass flowers)

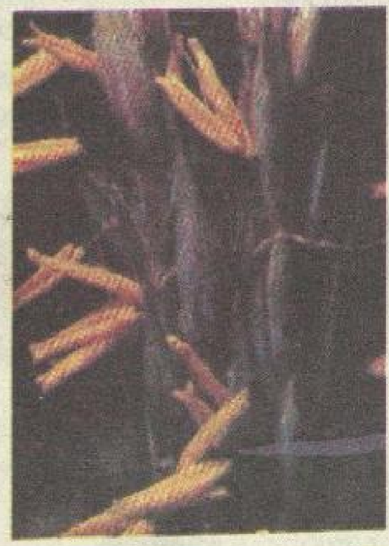


Fig. 16.8 (b) Wind pollinated flowers, showing the exposed anthers.

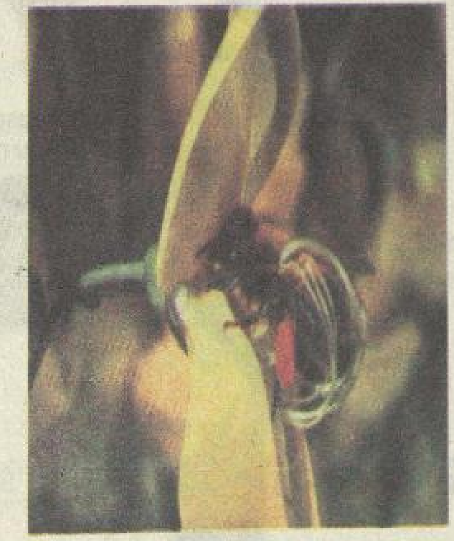


Fig. 16.8 (c) Insect pollinated flowers.

16.2.2 Importance of pollination in agriculture

Most of the plants used in agriculture are the flowering plants. Pollination leads to fertilization, forming seeds and fruits, which are used as food by us and other animals. If the process of pollination is damaged by the use of insecticides or pesticides through killing of insects, the fruit formation in orchards and seed formation in crops is severely affected leading to a gross financial loss to the growers on one hand and shortage of food on the other hand. Therefore, insecticides and pesticides should be used with great care.

16.3 Life cycle of Flowering Plant

The flowering plants show two generations i.e. sporophyte and gametophyte, which alternate with one another, during life cycle. A sporophyte is a dominant multicellular, diploid generation which is formed from zygote or fertilized egg. This generation produces spores (microspores and megaspores) by meiosis. The gametophyte is a small multicellular, haploid generation, which is formed from spores. The male gametophyte develops from microspore or pollen grain; and the female gametophyte develops from megaspore. The male and female gametophytes produce male and female gametes (sperms and eggs) by mitosis. The gametophytes in flowering plants are short lived, much reduced and dependent for protection on sporophyte.

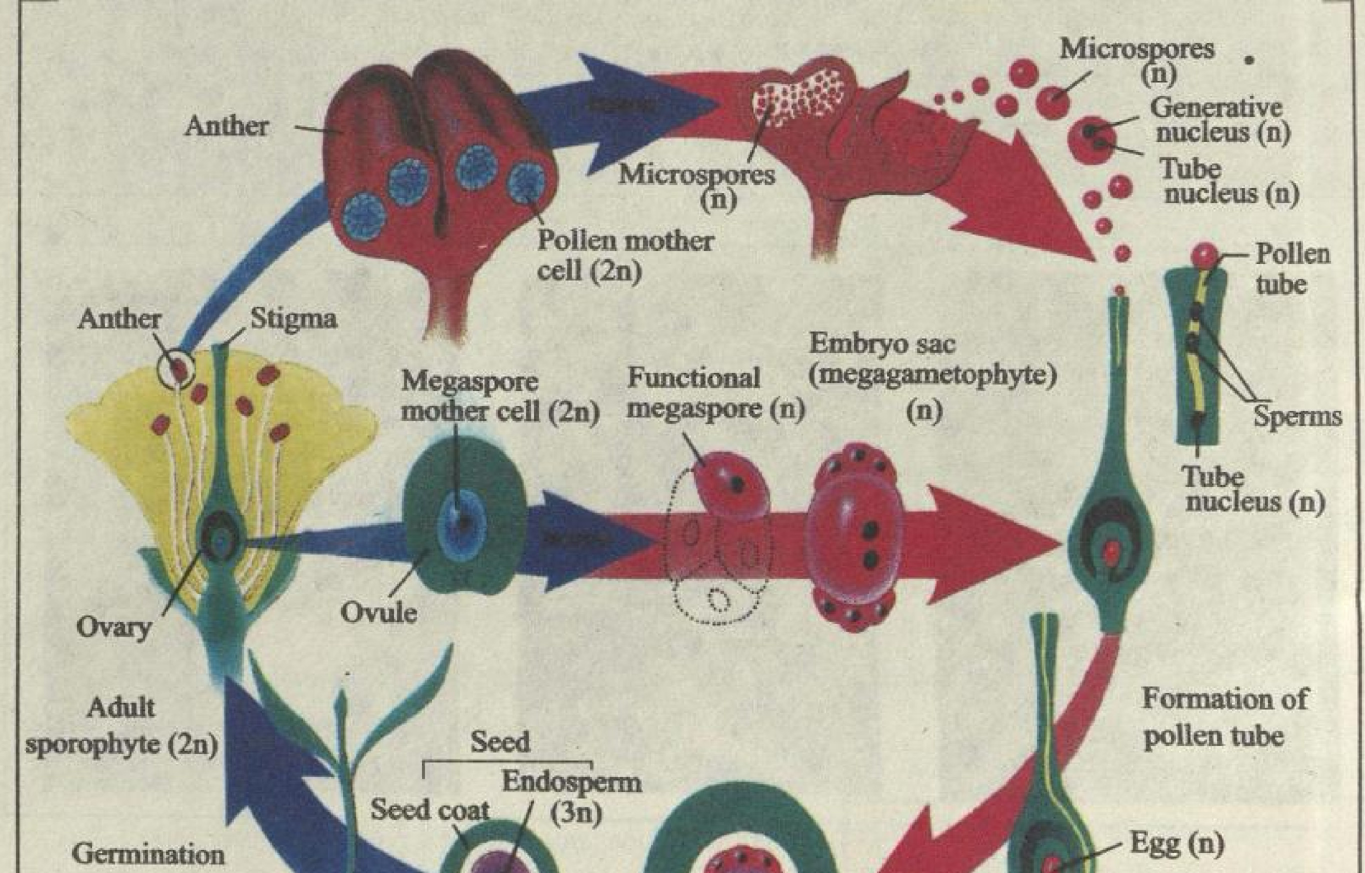

Anther
Microspores (n)
Pollen mother cell (2n)
Microspores (n)
Generative nucleus (n)
Tube nucleus (n)
Pollen tube
Anther
Stigma
Megaspore mother cell (2n)
Functional megaspore (n)
Embryo sac (megagametophyte) (n)
Sperms
Tube nucleus (n)
Ovary
Ovule
Adult sporophyte (2n)
Formation of pollen tube
Seed
Endosperm (3n)
Seed coat
Germination
Egg (n)
Endosprem cell (3n)
Embryo (2n)
Zygote (2n)

Fig. 16.9 Life cycle of flowering plant

Double fertilization

The pollen tube grows via style through micropyle into the ovule. The pollen tube nucleus facilitates the entry of the two sperm nuclei into the ovule. One of the sperm fuses with the egg to form diploid zygote, and the other sperm nucleus fuses with the two polar nuclei and forms triploid endosperm cell. This is called double fertilization, because two male gametes at a time fuse with two female cells. This process of double fertilization takes place only in the flowering plants.

Zygote develops into embryo and endosperm cell develops into food storing tissue, called endosperm. This is an important characteristic of flowering plants because food storing tissue is formed only after the zygote is formed.

16.4 Seed and Fruit Formation

Ovule after fertilization forms seeds. Zygote forms the embryo by mitosis. This consists of tiny radicle, a plumule with one or two short special leaves called cotyledons. Cotyledons store the food of endosperm in some seeds and become thick e.g. bean seed. The outer integument of ovule forms the testa and the inner integument forms tegmen. Testa and tegmen constitute seed coat. Seeds provide protection and nourishment to the embryo.

After the formation of seeds the ovary wall becomes fleshy or scaly and forms fruit wall. The floral parts i.e. sepals, petals, stamen, stigma shrivel and fall off. This ripened ovary with seeds is the fruit.

Parthenocarpic fruits may be formed by the ovary in which no fertilization occurs as it happens in fruits of banana, seedless varieties of grapes etc. In some other plants, unfertilized egg develops into new plant and this process is called **parthenogenesis.**

16.4.1 Dispersal of seeds and fruits

The seeds are the embryos of flowering plants in dormant stage. Fruits protect the seeds and help in the dispersal of the plant i.e. seeds and fruits may be carried a long distance from the parent plant. This reduces competition for light, water and other nutrients among the members of same species. The seeds and fruits may be dispersed by wind, by animals or by water.

1. Dispersal by wind

The smaller seeds and fruits are carried by wind to distant places. These seeds and fruits are light in weight and may also have wings or hairs. This helps them to be carried away by wind, away from the parent plant.

Examples are seeds of cotton, Bombax (sumbal), calotropis, grasses and Dandelion; and fruits of maple etc.

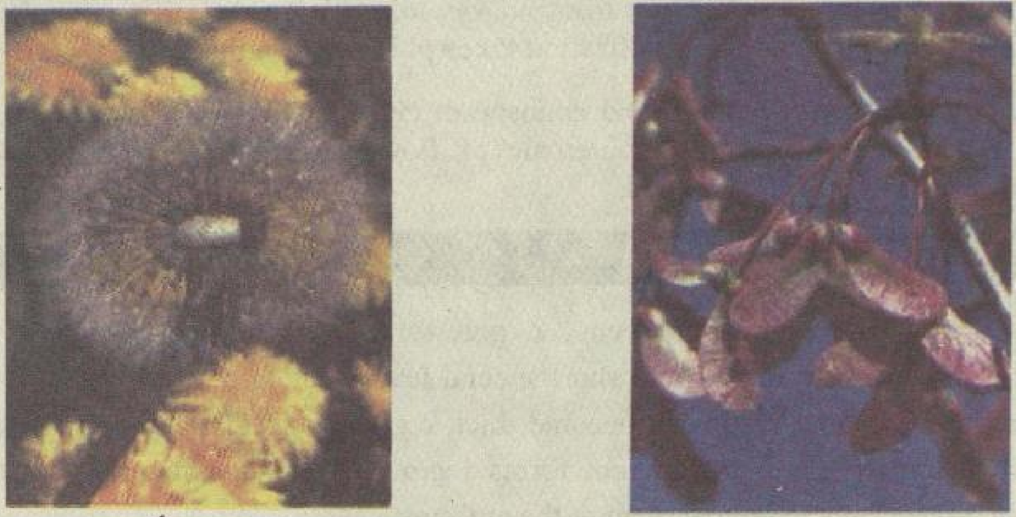
2. Dispersal by animals

The fruits and seeds of some plants have hooks or spines, which may be entangled in the fur of many mammals and are taken away from the site of parent plant. For example, medicago (maina), cocklebur, and Achyranthus (Puthkanda)

Some fruits and seeds are eaten by animals. The seeds are not digested and are passed out of the body of the animal alongwith faeces. Thus these are carried away from the site of the parent plant to new growing places e.g. guava, mulberry and ficus.

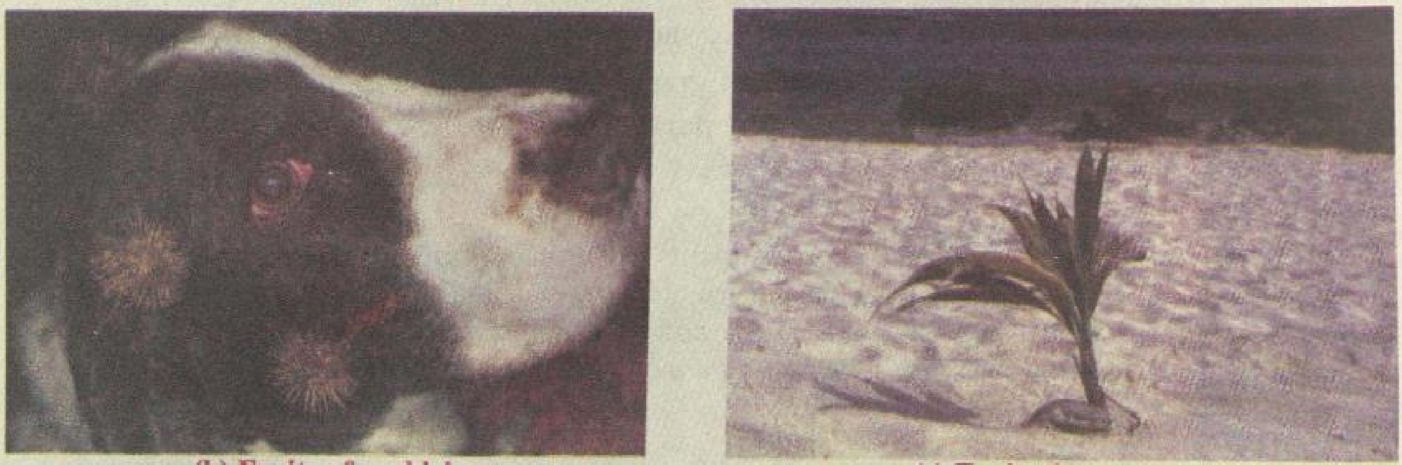
3. Dispersal by water

The fruits and seeds of some plants which grow in or near water are dispersed by water. The fruits of these plants may contain spongy tissues or fibrous fruit walls which allow them to float on the surface of water to be carried to distant places e.g fruit of lotus, coconut, and daffodils.



a (i)
Seeds of dandelion have filamentous tufts that are dispersed by wind.

a (ii)
Winged fruits of maple dispersed by wind.



(b) Fruits of cocklebur

(c) Fruit of coconut

Fig. 16.10 Examples of fruits and seeds. (a) dispersed by wind (b) dispersed by animals (c) dispersed by water.

16.5 Structure of Seed

A seed consists essentially of a seed coat, stored food and a young plant, the embryo. The seed coat may be made of inner tegmen and outer testa. On the seed coat a scar (**hilum**) is present which shows the place of attachment of a seed in the fruit is present. At one end of the hilum is the **micropyle**. Through micropyle the seed absorbs water during the process of germination.

, The embryo consists of epicotyl, one or two seed leaves called cotyledons, and a **hypocotyle**. The portion of the embryo above the point of attachment of cotyledons to embryo axis, and below the plumule is called epicotyl. The plumule forms shoot. The portion of the embryo below the point of attachment of cotyledons to embryo axis but above the radicle, is called hypocotyl. The radicle forms root.

The seed also contain the food, derived from the endosperm tissue. The food may remain as such or may be digested and stored in the cotyledons. Thus the cotyledons become thick due to the presence of stored food. This food is supplied to the developing plant during the process of germination of seeds. In the grain of maize, the cotyledon is modified into an organ called **scutellum** a term that comes from the Latin word meaning "Shield". The food stored in scutellum is used first during germination of seed. Later on scutellum absorbs the food of endosperm and supply it to the developing embryo.

The maize grain is infact a single seeded fruit in which seed coat fruit wall is fused.

Practical Work: Investigating structure of seed of gram and maize

With the help of hand lens locate micropyle and hilum of the two seeds.

With the help of scalpel cut the seeds longitudinally and observe different parts of the embryo along with endosperm with the help of (fig16.11).

1. What is the function of micropyle?
2. Why can't you find endosperm in gram seed?

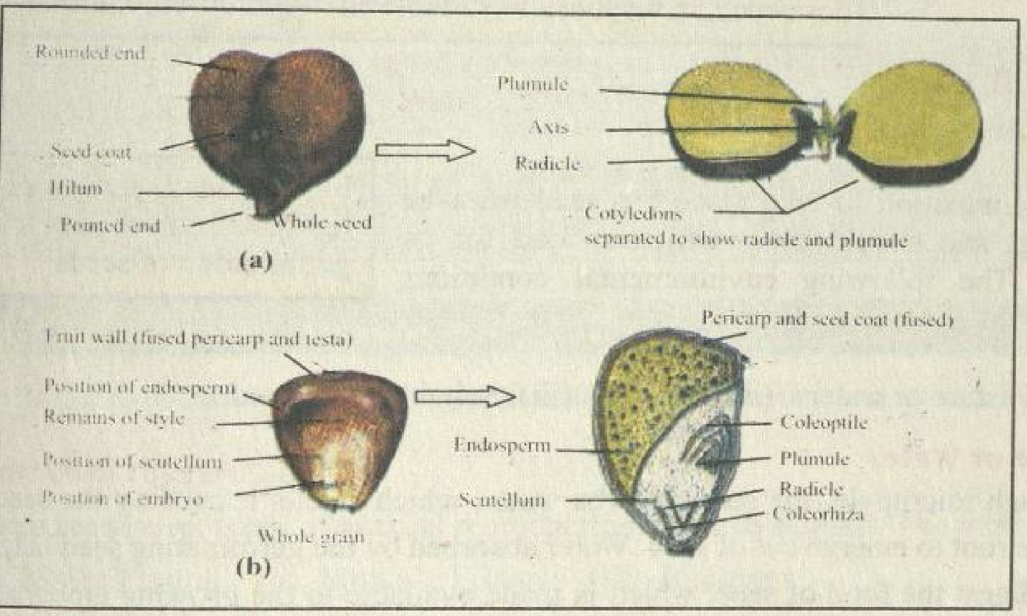

Rounded end
Seed coat
Hilum
Pointed end
Whole seed
(a)
Plumule
Axis
Radicle
Cotyledons separated to show radicle and plumule
Fruit wall (fused pericarp and testa)
Position of endosperm
Remains of style
Position of scutellum
Position of embryo
Whole grain
(b)
Pericarp and seed coat (fused)
Endosperm
Scutellum
Coleoptile
Plumule
Radicle
Coleorhiza

Fig. 16.11 Structure of seed of gram (a) and maize grain(b)

16.5.1 Seed germination

During germination (growth and development) of a seed the water is absorbed through micropyle, and the formerly dormant embryo resumes growth and emerges from the seed. The root is normally the first structure emerging from the seed, growing rapidly and absorbing water and minerals from the soil.

Much of the water is transported to the cells in embryo. As its cells elongate the stem pushes out of the soil. There are two types of germination, **epigeal** and **hypogeal**. When the cotyledons appear above

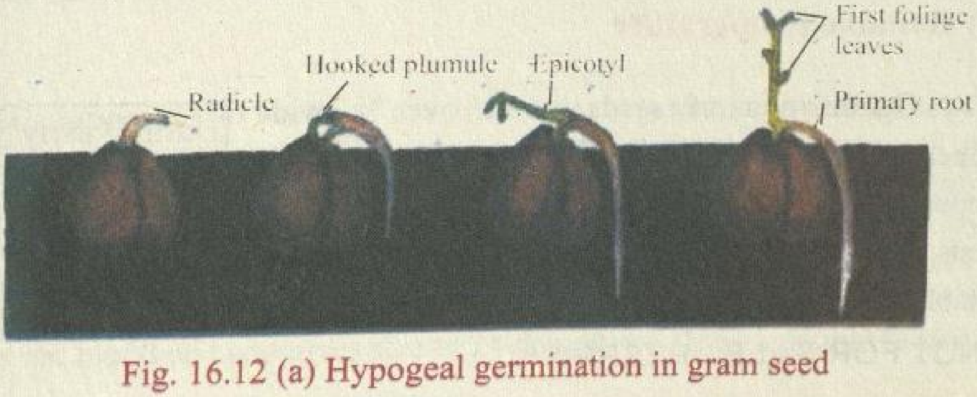
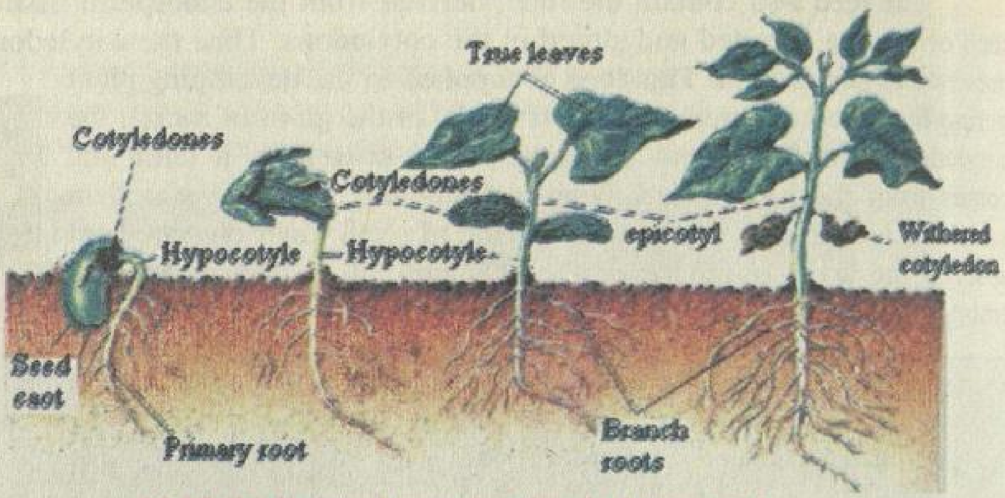

Radicle
Hooked plumule
Epicotyl
First foliage leaves
Primary root

Fig. 16.12 (a) Hypogeal germination in gram seed the ground by the elongation of hypocotyl, the type of seed germination is called epigeal, e.g. seeds of melons, cucumber and beans [Fig 16.12(b)].

When the cotyledons remain below the soil, and epicotyl elongates bringing only plumule above the soil surface, it is described as hypogeal germination, e.g. seed of gram and maize grain [Fig 16.12(a)].



16.12 (b) Epigeal germination in bean seed

Germination is the onset of growth of a seed, often following a period of dormancy, in response to suitable environmental conditions.

16.5.2 Conditions necessary for germination of seed

In some seeds such as of tobacco plant light is also necessary to trigger germination of seeds

For germination to take place the seed must be viable (living) and should have sufficient food for its germination. The following environmental conditions must exist.

(i) Moisture or water (ii) Air (O_2) (iii) Suitable temperature

(i) Moisture or water

Through micropyle, the seed absorbs water, which swells it causing the seed coat to burst. This helps the root to emerge out of seed. Water absorbed by the germinating seed helps to activate the enzymes to digest the food of seed, which is made available to the growing embryo. It also helps to elongate hypocotyl and epicotyl, to grow out.

(ii) Air

Because oxidative metabolism usually takes over soon after a plant embryo starts to grow, most seeds require oxygen for germination. So air is very important for germination as it contains about 21% of oxygen, which is used during respiration.

(iii) Suitable temperature

During early germination of seeds, the vital mobilization of food reserves stored in the embryo cotyledons or the endosperm is mediated by hormones, which in some cases are gibberellins

Germination of seeds occur over a wide temperature range between 5-30° C. The optimum temperature for the germination of seeds of most plants ranges between 25-30° C. Optimum or suitable temperature is necessary for the enzymes to function.

Practical work: Investigating the conditions necessary for germination

Set up four test tubes each with ten seeds labeled A, B,C and D as shown in Fig. 16.13.

Put tubes A, C and D in a warm place, in laboratory.

Put tube B in a refrigerator.

The test tube will have the following environmental conditions:

A. Water, suitable temperature and air

B. Water and the air (low temperature)

C. Suitable temperature and air

D. Water and suitable temperature (no air)

Observe the test tubes regularly for about one week.

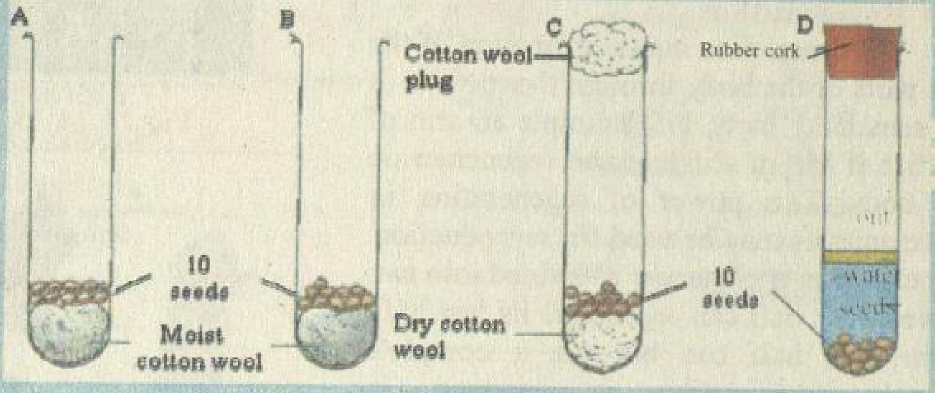


Fig. 16.13 Setup to investigate conditions necessary for the germination of seeds.

1. In which tubes the seeds germinate?
2. Did all the seeds in these tubes germinate, if not, why? Name the conditions necessary for the germination of seeds?

16.7 Reproduction in Animals

There are two main types of reproduction in animals, asexual and sexual.

16.7.1 Asexual reproduction

There are several types of asexual reproduction found in animals. The most common are:

(i) Binary Fission (ii) Multiple Fission (iii) Budding

(iv) Regeneration (v) Parthenogenesis

(i) Binary fission

It is the simplest method of asexual reproduction at the level of unicellular organisms. In this process, the unicellular organism divides into two identical daughter cells. During the process, the nucleus becomes elongated followed by the constriction of the cytoplasm. Then the nucleus divides into two and the cell afterwards also divides into two. This is common in *Amoeba* and *Paramecium*.

(ii) Multiple fission

This is a process of repeated divisions of the unicellular organisms into many small cells. In this process nucleus divides into many nuclei followed by the division of parent cell into many daughter cells. For example Amoeba becomes enclosed in a covering or cyst under the unfavorable conditions. Its nucleus divides into many nuclei and each nucleus becomes surrounded by a bit of cytoplasm. When the conditions become favourable, the cyst ruptures and a large number of daughter amoebae are released. Another example is that of malarial parasite, the *Plasmodium*. In this case, each *Plasmodium* enters red blood cell and gives rise to 24 daughter cells by multiple fission.

(iii) Budding

In this process an outgrowth or bud develops by mitosis on the body of parent organism. It grows to a new individual, which either separates immediately or may remain attached to the parent body for sometime. It is commonly found in *Hydra*.

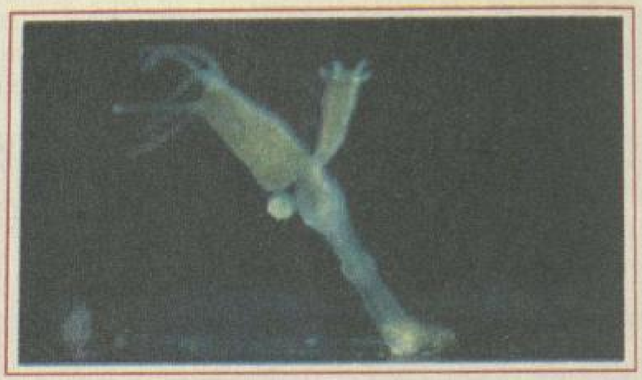


Fig 16.14 Budding in *Hydra*

(iv) Regeneration

Regeneration means formation of the lost parts of the body through the growth of the remaining parts. For example an arm of starfish if lost in accident can regenerate on the body. This power of regeneration in some animals may be used for reproduction. For example, if planarian is divided into two halves, each half can regenerate its lost half. Thus each half can become a complete animal. Regeneration is common in annelids, echinoderms and flatworms.

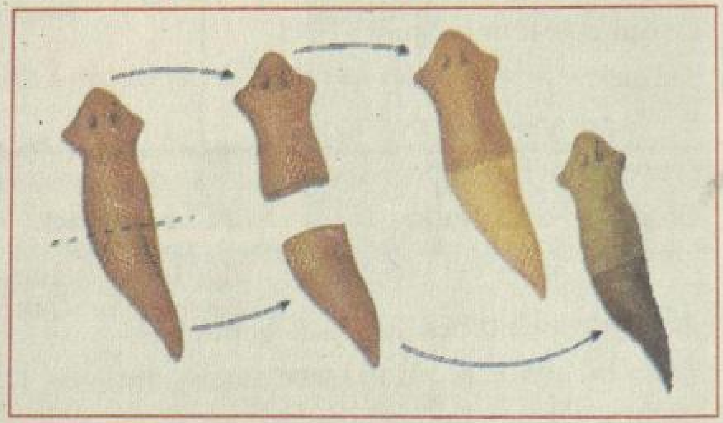


Fig 16.15 Planaria reproduces by dividing across the middle. Then each offspring regenerates the missing half of its body.

(v) Parthenogenesis

This is a modified form of sexual reproduction in which an unfertilized egg develops into a complete individual . For example in the honey bees, the queen lays eggs which are either fertilized to form diploid **workers**, or if not fertilized it forms the hapliod males called **drones**. In rotifers, parthenogenesis is a common process of reproduction.

16.7.2 Sexual reproduction

The sexual reproduction is based on the fusion of two halpoid cells (gametes) to form a diploid zygote. In multi-cellular animals the sexual reproduction is based on **meiosis**, which results inthe formation of specialized sex cells called gametes. The two gametes from two parents, or from one parent (in the case of self fertilization) unite together to form zygote which is the first diploid cell of the new generation.

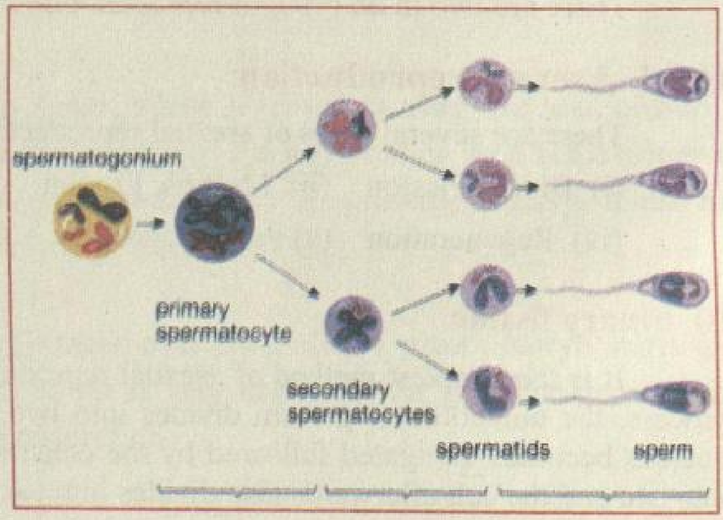


Fig 16.16 (a) Spermatogenesis

The gametes are of two types: male gametes or sperms and female gametes or eggs. The male gametes are formed in testes while the female gametes are formed in ovaries. Testes and ovaries are known as male and female gonads respectively. The production of sperms is called **spermatogenesis** while production of ova or eggs is called **oogenesis** (Fig 16.16). Gametes form the physical link between the parent generation and the offspring.

The meiosis plays the fundamental roles in sexual reproduction. It provides the mechanism for reducing the number of chromosomes to one half in gametes and for the exchange of genetic material in chromosomes by the phenomenon of crossing over. The diploid number of chromosomes in the zygote provides the genetic make up for the new individual. The zygote, by simple mitosis changes into embryo, and the embryo develops into a new individual by **cell division, differentiation** and **growth**.

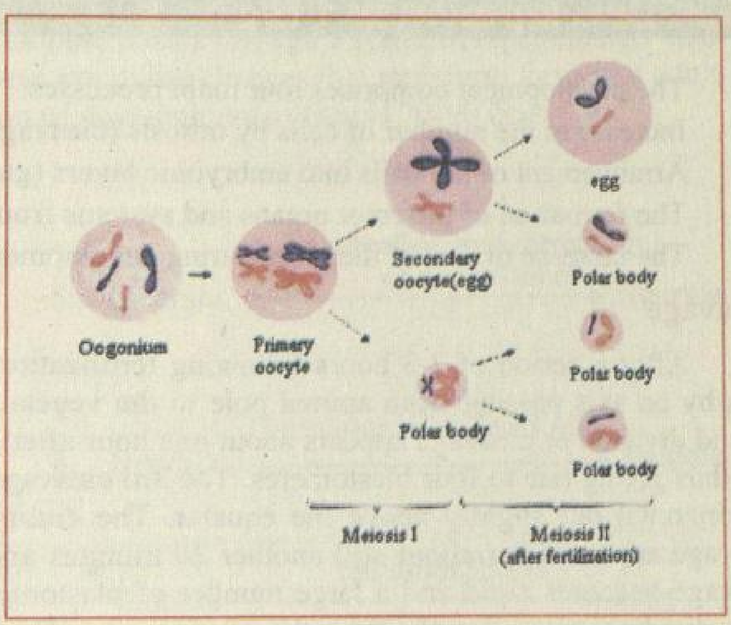


Fig 16.16 (b) Oogenesis

Table 16.2 Comparison of asexual reproduction with sexual reproduction

	Asexual Reproduction	Sexual Reproduction
1.	Only one parent in involved	Two parents, take part
2.	No meiosis , No gamete formation	Meiosis takes place and gametes are formed.
3.	No fertilization	Fertilization takes place
4.	No variations, offspring are identical to their parents	Genetic recombination occurs leading to variations
5.	Rapid production of large number offspring	Less rapid increase in number

16.7.1 Reproduction in frog

A fertilized egg or zygote of frog passes through a series of events to form an adult animal. The process involving these events is known as **development**. The developing individual in its early stages is called an embryo and in placental mammals at the later stage it is called a **foetus**. The study of embryo is called **embryology**.

Fertilization

The eggs are produced in paired thin walled sacs called **ovaries** located in the abdomen. Each egg is a small ball spherical structure having one half pigmented, called animal hemisphere, the other half yellowish due to the storage of food or yolk, and is called vegetal **hemisphere**. The middle of these two halves is called equator. The animal hemisphere or the upper half contains the nucleus of the egg cell. After the sperm enters the egg a small greyish crescent shaped area called grey crescent is formed on one side of the animal hemisphere close to the equator.

The male sex cells or sperms are produced in a pair of testes, during their breeding season. Female releases eggs and male release sperms in water, where fertilization takes place this is called **external fertilization.** Fertilization results in the formation of zygote.

16.8 Development of Frog

The development comprises four main processes:

(i) Increase in the number of cells by mitosis (cleavage)

(ii) Arrangement of the cells into embryonic layers (gastrulation)

(iii) The formation of different organs and systems from the embryonic layers (organogenesis)

(iv) The increase in size of the body during development (growth)

Cleavage

After a period of 2-3 hours following fertilization, the fertilized egg starts dividing into two cells by an axis passing from animal pole to the vegetal pole. Each cell is called **blastomere**. The second division or cleavage appears about one hour after the first cleavage, at right angles to the first one thus giving rise to four blastomeres. The 3rd cleavage starts after about another half an hour and is horizontal but slightly above the equator. The embryo now has eight blastomeres. The fourth cleavage appears after about still another 20 minutes and divides the cells vertically. After this the cleavage becomes rapid and a large number of blastomeres of unequal sizes are formed, the upper cells dividing more rapidly than the lower ones. This cleavage or **segmentation** results in the formation of a solid ball of cells, which is called **morula**.

Blastulation

Soon after the formation of morula, a series of changes starts that leads to **blastulation**. A cavity appears due to compact rearrangement of cells within the embryo in the upper half, called **bastocoel**. The embryo at this stage is called **blastula** and is a hollow ball of cells. Now the cells move to occupy their new position according to the function they have to perform.

Gastrulation

The formation of blastula leads to the movement and rearrangement of cells to occupy their definitive position. The smaller pigmented cells spread over the large yolk cells, except a small circular area called **yolk plug**. This is the area where a circular depression called blastospore starts appearing. The cells along the margin of the blastopore move inward (infold) to form the mesoderm and endoderm. The mesoderm formed behind the dorsal lip gives rise to the **notchord**. The ectoderm gives rise to the outer layer of skin and nervous system. The endoderm gives rise to digestive and some part of respiratory systems. All the other systems are formed from mesoderm. In the meantime, a cavity called **archenteron** appears, enlarges and becomes lined with the endoderm. At this stage the embryo is called gastrula and all the changes which result in the conversion of blastula into gastrula are collectively known as gastrulation.

Neurula

The dorsal ectoderm differentiates into the neural tube to form the nervous system. This process is called **neurulation**. At this stage the embryo becomes elongated, develops cilia, swims freely, and is called **neurula**.

Tadpole

After neurulation rapid changes occur in the different cellular layers to form different organs and systems of the body that convert the embryo into the larva called **tadpole**. The tadpole is apparently fish-like in shape having external gills, internal gills and a long tail. It swims by undulation of its body.

When tadpole larva is formed, the stored food in the form of yolk has been consumed and the larva starts feeding on vegetation.

Metamorphosis

After an active free swimming phase, the tadpole passes through a series of rapid changes that transforms it into the tailless adult frog. The process involving changes that transform larva into adult is known as **metamorphosis**. The average duration of development of frog is 70-90 days

1. Egg + Sperm $\xrightarrow{\text{fertilization}}$ Zygote
2. Zygote $\xrightarrow{\text{rapid cell division or cleavage}}$ Morula
3. Morula $\xrightarrow{\text{formation of blastocoel}}$ Blastula
4. Blastula $\xrightarrow[\text{formation of 3 germinal layers (gastrulation}]{\text{re-arranging of cells and}}$ Gastrula
5. Gastrula $\xrightarrow{\text{elongation and formation of neural tube}}$ Neurula
6. Neurula $\xrightarrow{\text{formation of tail and gills}}$ Tadpole
7. Tadpole $\xrightarrow{\text{metamorphosis}}$ Frog

A summary of development of frog

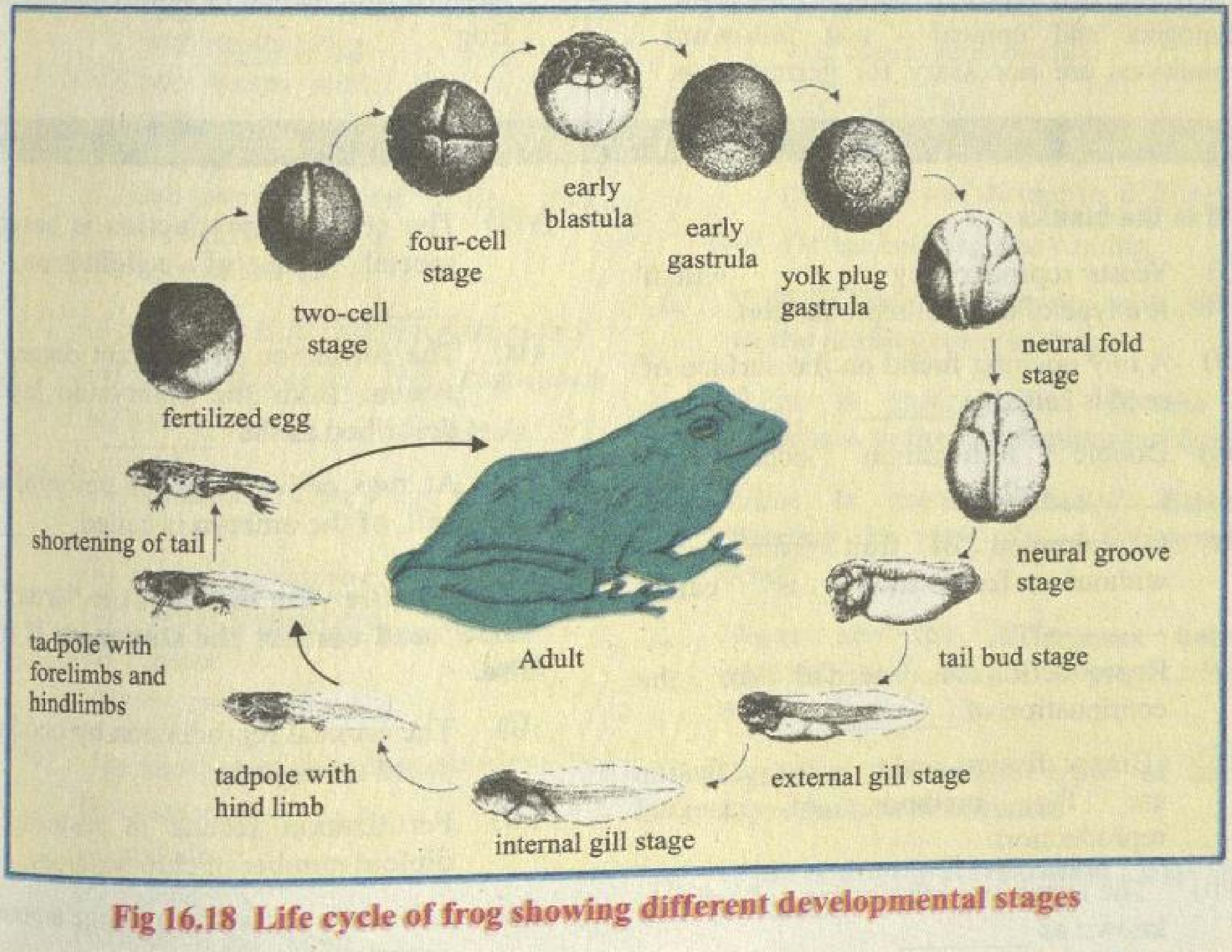

early blastula
four-cell stage
early gastrula
two-cell stage
yolk plug gastrula
neural fold stage
fertilized egg
shortening of tail
neural groove stage
tadpole with forelimbs and hindlimbs
Adult
tail bud stage
tadpole with hind limb
external gill stage
internal gill stage

Fig 16.18 Life cycle of frog showing different developmental stages

KEY POINTS

1. Reproduction is a biological process leading to the production of new individuals, of ones own kind.
2. There are two main types of reproduction in organisms asexual and sexual.
3. Some of the different types of asexual reproduction in organisms are binary fission, multiple fission, spore formation, budding, parthenogenesis, regeneration and vegetative propagation in plants.
4. During sexual reproduction of flowering plant pollination plays an important role.
5. Double fertilization in flowering plants. leads to the formation of seed and fruit.
6. Seed contains embryo and also contains food for the development of embryo.
7. Seeds and fruits help in dispersal of plants.
8. There are two types of seed germination, hypogeal and epigeal - and following conditions are necessary for germination, viability of seeds, water, air and suitable temperature.
9. In most animals sperms are produced by spermatogenesis and eggs are formed by oogenesis.
10. In frog fertilization is external and is in water.
11. Cleavage is rapid cell division by which zygote changes into a solid ball of cells called morula.
12. Blastula is formed when ball of cell contains a cavity called blastocoele.
13. Gastrula is characterized by the formation of three germinal (embryonic) layers.
14. Neurula is a developmental stage which has developed nervous system in the form of neural tube.
15. Metamorphosis is a process by which the larva of frog, called tadpole, changes into a frog.

QUESTIONS

1. Fill in the blanks

(i) Yeasts reproduce by ________ which is a type of asexual reproduction.

(ii) A tiny opening found on the surface of seed is called ________.

(iii) Double fertilization occurs in ________ plants.

(iv) Development of fruit from ovary without fertilization is called ________.

(v) Reproduction is needed for the continuation of ________.

(vi) Binary fission and ________ fission are the methods of asexual reproduction.

(vii) The testes and ovaries are collectively known as ________.

(viii) The sexual reproduction is based on special type of cell-division, the ________.

(ix) The formation of different organs and system from the embryonic layer is described as the ________.

(x) At two celled stage of embryo, each cell, of the embryo is called ________.

2. Write weather the statement is "true" or "false" and correct the statement if it is false.

(i) The asexual reproduction by budding is based on meiosis.

(ii) Fertilization results in restoring the diploid number of chromosomes.

(iii) Mitosis is the source of huge amount of genetic variability.

3. Each question is followed by four options. Encircle the correct answer.

(i) When a bee gets nectar from a flower, it picks up pollen from;

(a) stigma (b) ovary
(c) sepals (d) anthers

(ii) In plant the gametophytes produces egg and sperms by

(a) mitosis (b) meiosis
(c) spore formation (d) fertilization

(iii) If you found a dark, rotten smelling flower near the ground it would most likely be pollinated by

(a) bats (b) bees
(c) moth (d) beetles

(iv) Fertilization is flowering plants is called double fertilization because

(a) one tube nucleus fuses with one egg and one sperm nucleus fuses with another egg.
(b) two sperm nuclei fuse with one egg.
(c) one sperm nucleus fuses with egg and another sperm nucleus fuses with fusion nucleus
(d) none of the above

(v) In peach, the fruit is derived from the

(a) wall of the ovary (b) megaspores
(c) endosperm (d) petals

(vi) The nucleus of frog's egg is located in the;

(a) animal hemisphere
(b) vegetal hemisphere
(c) equator
(d) grey crescent

(vii) The intestine of frog from develops from;

(a) ectoderm
(b) endoderm
(c) mesoderm
(d) none of the above

(viii) As soon as the nervous system is formed, the embryo becomes:

(a) neurula (b) morula
(c) blastula (d) gastrula

4. Give short answers of the following questions.

(i) What is the difference between animal pole and vegetal pole.

(ii) Do you think the internal fertilization is found in frog?

(iii) What is the real purpose of the phenomenon of reproduction in animals?

(iv) Why the name neurula is given to a specific stage of the embryo of frog?

(v) What do you think are the main events of gastrulation process?

(vi) Is blastulation and gastrulation one and the same thing?

(vii) What are differences between asexual and sexual reproduction

(viii) What is a clone?

(ix) What do you mean by vegetative propagation? Name its different types

(x) Define budding and cloning.

5. Write a note on cleavage with reference to the development of frog.

6. What is gastrulation? Discuss with reference to the development of frog.

7. What is metamorphosis? Elaborate keeping in view the development of frog?

8. What are the differences between asexual and sexual reproduction in animals?

9. Describe the major types of asexual reproduction in animals.

10. What is double fertilization? Explain the process.

11. Describe the sequence of events from pollination to fertilization in flowering plants.

12. Explain how seeds and fruits are dispersed.

13. Describe different methods of asexual reproduction in plants.

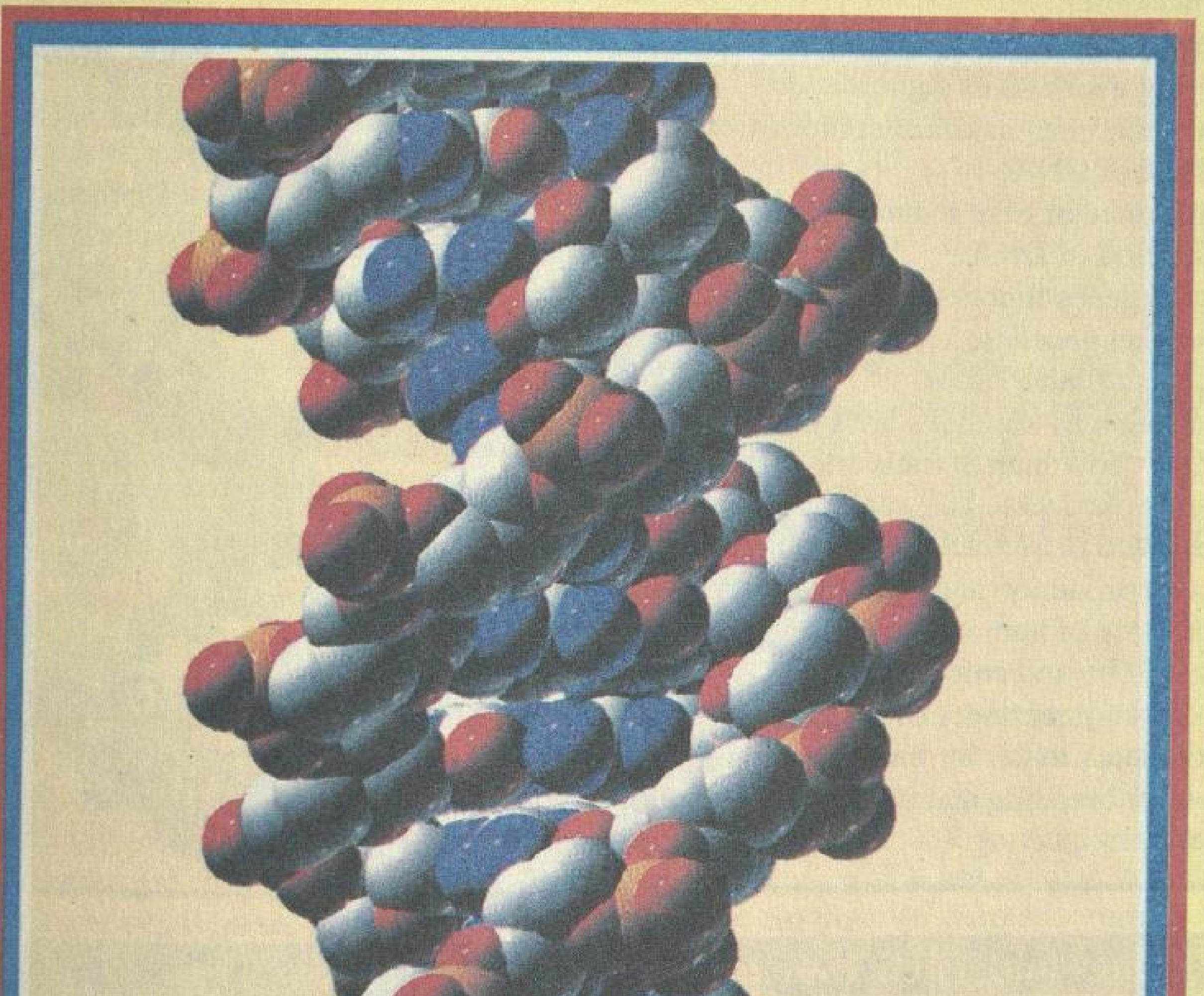
14. What is pollination? Name its types. Give the characteristics of insect pollinated and wind pollinated flowers.

15. What are the conditions for germination of seed? Explain their role in the process of germination of seed.

Section

6

Genetics and Evolution

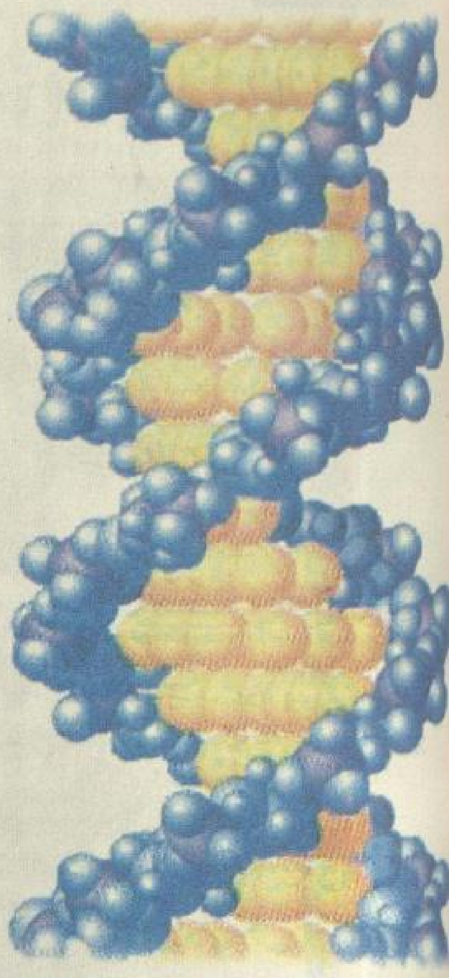


17

GENES AND INHERITANCE

In this chapter you will learn:

- Heredity, genes and their role in biological inheritance.
- Relationship between genes and chromosomes.
- Alleles, their origin and impact.
- Crossing over and its significance
- What genes are; chemical composition and structure of DNA.
- Significance of base sequence in DNA, Replication of DNA.
- How do genes function to produce traits?
- Mendelian genetics; Mendel, his superb work and laws of inheritance.
- Application of Mendel's laws in human genetics; how human traits and hereditary diseases like sickle-cell anaemia are transmitted in Mendelian fashion.
- Sex determination and sex linkage in man. Inheritance of human hereditary diseases like haemophilia and colour-blindness.
- Genetic engineering; how is DNA manipulated in lab for human welfare.
- Selective breeding and its comparison with genetic engineering.



17.1 Genes and Their Role in Biological Inheritance

Have you ever had such a fascinating experience that a stranger had recognized you at glance, that whose child you are or whose sib you are? How was he able to make such an accurat guess? Was it your charming smile that resembled that of your mother, or your face line was like tha of your father? Have you ever noticed which of your features; your hair or eye colour, your nose o earlobes, your lips and your teeth, your hands or your feet are like those of your parents o grandparents? Your observation is perfectly right. You resemble your parents, and they resemble their parents. It is a unique fundamental phenomenon of life. A cub looks like a lion, and a kitten lik a cat; a puppy like a dog, and a froglet like a frog. This "likeness" generation after generation is due to heredity. **Heredity** is passing on of characteristics from parents to children.

Life in every organism; every character of his structure, function, metabolism and behaviour, at all levels of biological organization is programmed and controlled by a set of instructions. These instructions are in the form of coded biological information called **genes**. You have received your genes from your parents, and they have received their genes from their parents. Thus you and your sibs share many genes of your parents and even of your grandparents. Inherited characters are determined by genes. These are transmitted from generation to generation through genes. **Heredity is the way genes transmit traits from parents to offspring.**

Genes are the units of inheritance because these determine inherited characters. The terms 'heredity' and 'inheritance' are more or less synonymous. Biological inheritance is the passage of traits determined by genes from one generation to the next.

The word "genetics" is derived from "genes". **Genetics** is the science of heredity. **It is the study of structure and behaviour of genes. Gene** is the basic unit of biological information. Genetics deals with transfer of biological information in the form of genes from parents to offspring; i.e., from generation to generation.

17.1.1 Gamete – A vehicle of inheritance

Your life has started as a single cell – the zygote. All the cells of your body arose from it through mitosis. It was not just an ordinary cell; rather it was the pioneer representative of your identity. Its nucleus had a complete programme of coded genetic information for your developing into a unique individual. Each cell of your body descended from it, has received the same set of genes. The development of your entire personality at all stages of your life; from embryo through baby, child hood, youth to old age is under the direction and control of this complete set of genes – your very personal **genome**.

How was your zygote formed? Yes! It was formed by the fertilization of your paternal and maternal gametes. Those two tiny cells – a sperm and an egg provided the only possible physical link between you and your parents. Anything to be transmitted between generations must pass through this genetic bridge. But how? Nucleus is the master – organelle of every cell. It controls all activities of cell. The most significant structures in the nucleus are chromosomes. They were discovered by Waldeyer in 1876.

17.1.2 Organisms have number of chromosomes specific to their species

Each kind of organism has a specific number of chromosomes. This number remains constant in all individuals of a species generation after generation. The nucleus of your zygote and each somatic cell of your body that arose from it contain 46 chromosomes. It is the diploid **(2n)** no. of our species *Homo sapiens*. Similarly frog's species constant number is 26; and for Garden Pea it is 14. These chromosomes are in the form of pairs. Two chromosomes, which are similar in their shape, size and position of centromere, make one **homologous pair**. So your 46 chromosomes are actually 23 pairs of homologous chromosomes. Each member of a homologous pair is called a **homologue.** One homologue of each pair comes from father; the other homologue comes from mother. Thus every cell of your body contains **two sets of 23 chromosomes each**. One haploid set **(n=23)** is paternal in origin, which has been contributed by the sperm nucleus, while the other haploid set (n=23) is maternal which has come from the egg nucleus. These two sets of chromosomes have provided the physical basis of your heredity.

17.2 Where are Genes Located ?

Each chromosome carries a number of genes on it. Genes are linearly arranged at specific positions on chromosomes. **The position of a gene on the chromosome is called its locus**. It is its home. The linear order of the gene loci on one homologue corresponds to that of its partner homologue. **Karyotype** is the entire chromosome complement of an individual or cell, while **genome** is the total amount of genetic material in a chromosome set of an individual.

All the genes present on a chromosome are linked to each other. This phenomenon of staying together of all the genes of a chromosome is called **linkage**. Wherever a chromosome moves, it carries its riding genes en bloc in the form of a **linkage group**.

The number of linkage groups corresponds to the number of homologous pairs of chromosomes. You have 23 linkage groups. How many does a frog have?

17.2.1 Alleles —Their origin and impact

Like chromosomes, genes also form pairs. Partners of a gene pair are called **alleles**. Each allele of a gene pair occupies the same gene locus on its respective homologue. The partner genes or alleles may be identical to each other; i.e., each other's **true copies**, or slightly different from each other, **altered copies**. These altered, alternative forms of a gene arise by a sudden change in the structure of a gene. This change is called **gene mutation** (Fig 17.1).

Gene A $\xrightarrow{\text{mutation}}$ a

Gene B $\xrightarrow{\text{mutation}}$ b

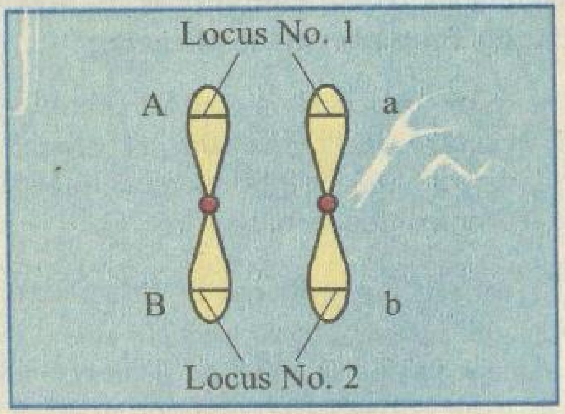


Fig 17.1 Linkage: Allelic pairs on a homologous pair of chromosomes.

17.3 Crossing Over and Its Significance

Recall **synapsis** during Prophase I of Meiotic I, when homologous chromosomes pair up lengthwise, point-to-point, and locus to locus. Each homologue consists of two sister chromatids with identical genes. **Chiasmata** or x–shaped cross-links are formed between non-sister chromatids. An exchange of segments between non-sister chromatids of homologous chromosomes occurs at the chiasmata, which is known as **crossing over**. As the alleles of non - sister chromatids are different, crossing over results in **recombination of genes** (Fig 17.2).

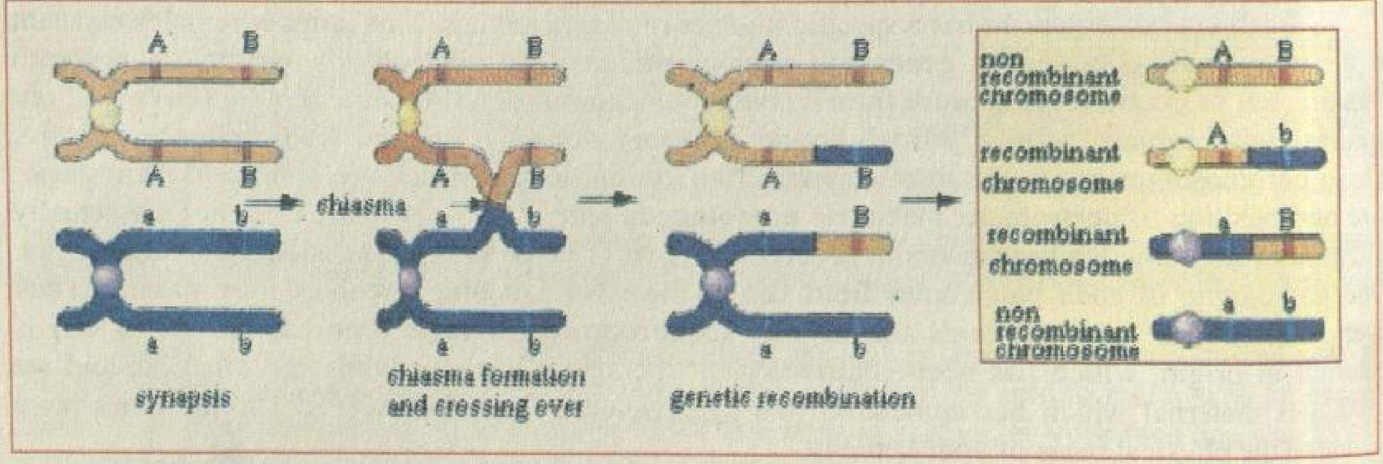


Fig 17.2 Crossing over produces genetic recombination

In the example shown in the figure allele 'b' crosses over to homologue containing 'A' and allele 'B' comes on homologue of 'a'. When the chiasma opens up, the homologous chromosomes separate from each other. The sister chromatids also become

Closer the two gene loci, more strongly are their genes linked. The farther apart two genes lie greater are the chances of their separation through crossing over.

separated to form chromosomes in four gametes. The two gametes would have parental combination of genes; i.e., 'A' with 'B' and 'a' with 'b', whereas two gametes would have chromosomes with new combinations of genes, i.e., 'A' with 'b' and 'a' with 'B'.

17.3.1 Significance of crossing over

Gametes with varied combination of genes resulting from crossing over produce genetic variation in offspring. Genetic variations among offspring lead to tremendous variety in their traits. These variations provide raw material for evolution. They may have genetic make up better than their parents to let them adapt to the changing environment in a much better way.

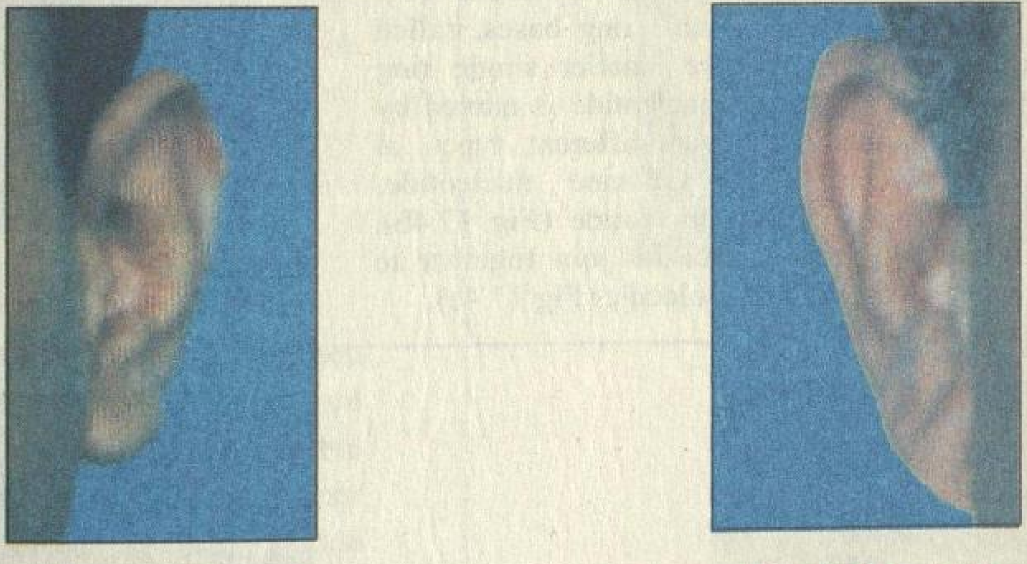
Mutations may give rise to even more than two alternate forms of a gene. Some genes may have as many as 300 alleles. All such alleles (more than two) are called **multiple alleles**. A diploid individual can have any two of these multiple alleles in his genome. In the genome of a haploid organism or in gametes, each gene represents itself as a single allele.

Phenotype

Phenotype is the form of appearance of a trait in an individual.

Genotype

Genotype is the genetic complement – the genes in an individual for a particular trait.



Free earlobes

Attached earlobes

Fig 17.3 Phenotypes of ear lobes.

Traits with a few phenotypes are determined by a few alleles of a gene. Traits with many phenotypes need many alleles of different genes.

Traits may be simple, complex or very complex. Usually a simple trait has at least two distinct phenotypes. e.g.; Ear lobes may hang freely or attach to the cheeks (17.3). Each type of expression is determined by a different allele of the gene. Allele 'A' is determiner for free earlobes, while allele 'e' is determiner for attached earlobes. More the number of different alleles of a gene controlling a trait, more will be the number of their different forms of expression into different phenotypes. e.g.; Human blood group is a complex trait. It has four phenotypes A, B, AB and O. Three multiple alleles I^A, I^B, and i take part to make these four phenotypes. Human eye colour is a more complex trait. It has many phenotypes like black, brown, hazel, green, and blue. It needs many gene pairs with their respective alleles to make its many different phenotypes.

17.4 DNA – The Genetic Material

In Prophase, chromatin material condenses into chromosomes. Chemical analysis of chromatin shows that it is composed primarily of Deoxyribonucleic acid (**DNA**) and **proteins**. These are organic molecules.

DNA is the genetic material. It is a long molecule about 2 nm thick. It runs continuously within each chromosome. **Genes are short lengths of DNA in chromosomes.** DNA is acidic in nature.

17.4.1 Chemical composition of DNA

DNA is a complex macromolecule. **Macromolecules** are very large molecules. It is composed of repeating sub-units called **nucleotides**. Nucleotides are joined together in long chains called **polynucleotides**. The nucleotides of DNA are deoxyribonucleotides. Each deoxyribonucleotide is made up of : (Fig 17.4a)

1. a phosphate group,
2. a deoxyribose sugar, and
3. a nitrogenous base.

There are four different nitrogenous bases: **Adenine (A), Guanine (G), Thymine (T) and Cytosine (C).** Adenine and Guanine are larger double ring bases, called **Purines.** Cytosine and Thymine are smaller single ring bases called **Pyrimidines.** As each nucleotide is named by the base it contains, there are four different types of nucleotides; Adenine nucleotide, Guanine nucleotide, Thymine nucleotide and Cytosine nucleotide (Fig 17.4b). Many of these four types of nucleotides join together to form polynucleotide chain of DNA molecule (Fig 17.4c).

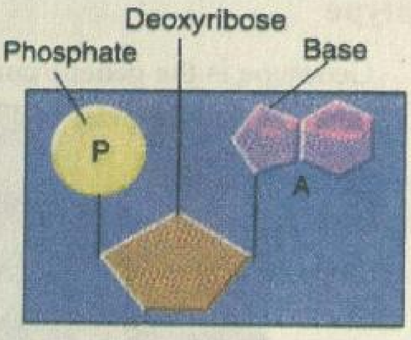
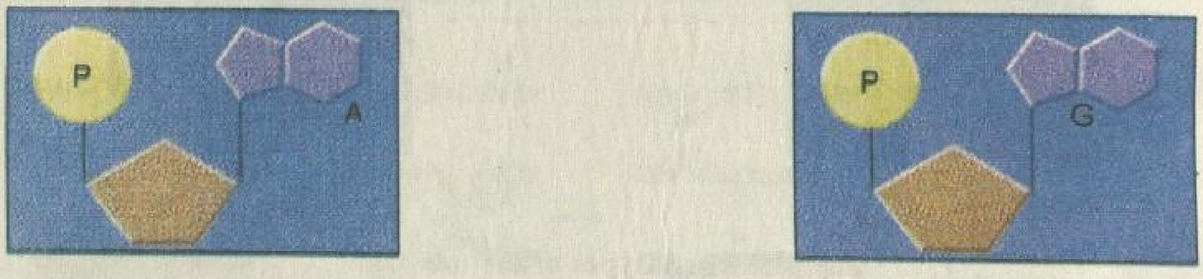
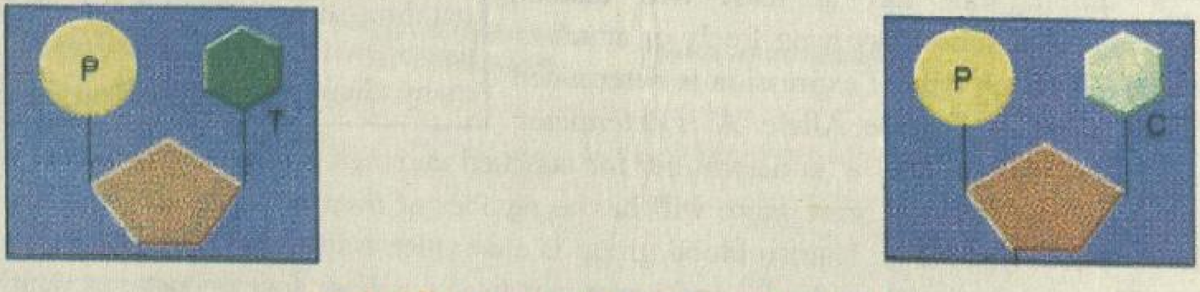


Fig 17. 4(a) A nucleotide



purine nucleotides are larger in size



pyrimidine nucleotides are smaller in size

Fig. 17. 4 (b) : Nucleotides of DNA

17.4.2 Structure of DNA – Watson and Crick's model

In 1953, James Watson and Francis Crick gave the model for the structure of DNA. They proposed that DNA molecule is made up of two polynucleotide strands, which are twisted around each other in the form of a **double helix.** The double helix looks like a spiral staircase of uniform diameter(Fig. 17.5). The railings of this staircase are composed of deoxyribose sugars and phosphates, while the steps are made of pairs of nitrogenous bases. Each step consists of a purine paired with a pyrimidine. **Their pairing is highly specific**. Adenine always pairs with thymine, and guanine always pairs with cytosine. Two hydrogen bonds are formed between A and T, while three hydrogen bonds are formed between G and C.

$$A = T,\ G \equiv C$$

Nitrogen base pairing between adenine and cytosine or between guanine and thymine is not possible because such hydrogen bonds cannot be formed. The two polynucleotide strands are held together in their helical configuration by these hydrogen bonds between bases in opposing strands. The base pairs in DNA are 0.34 nm apart, and each turn of the double helix has 10 base pairs. The sugar phosphate backbones of the two complementary strands are anti-parallel (↑ ↓) due to opposite chemical polarity.

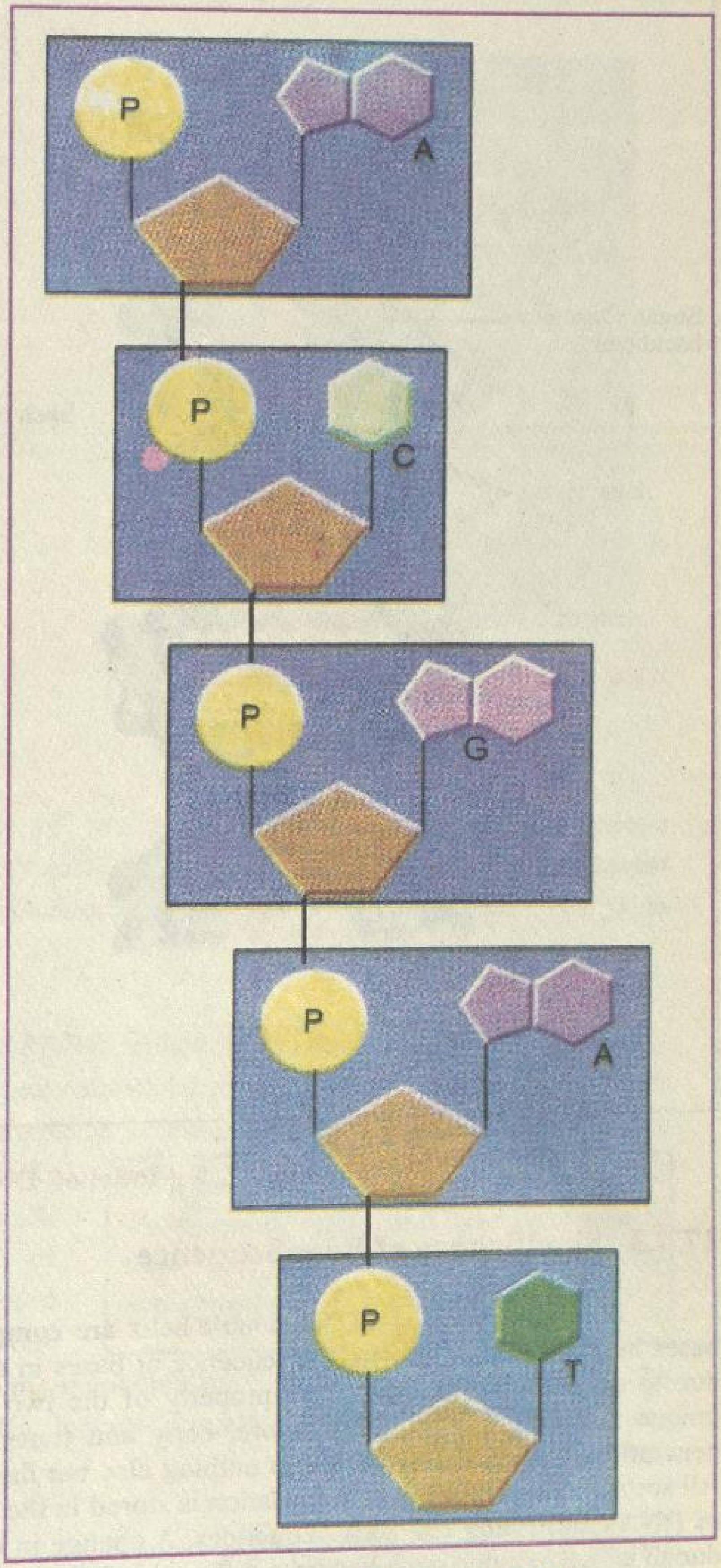


Fig 17.4(c) Polynucleotide chain of DNA

C M Y K Ch. Scan Ph:7238069 Client Name: Shoaib Date: 18-9-07

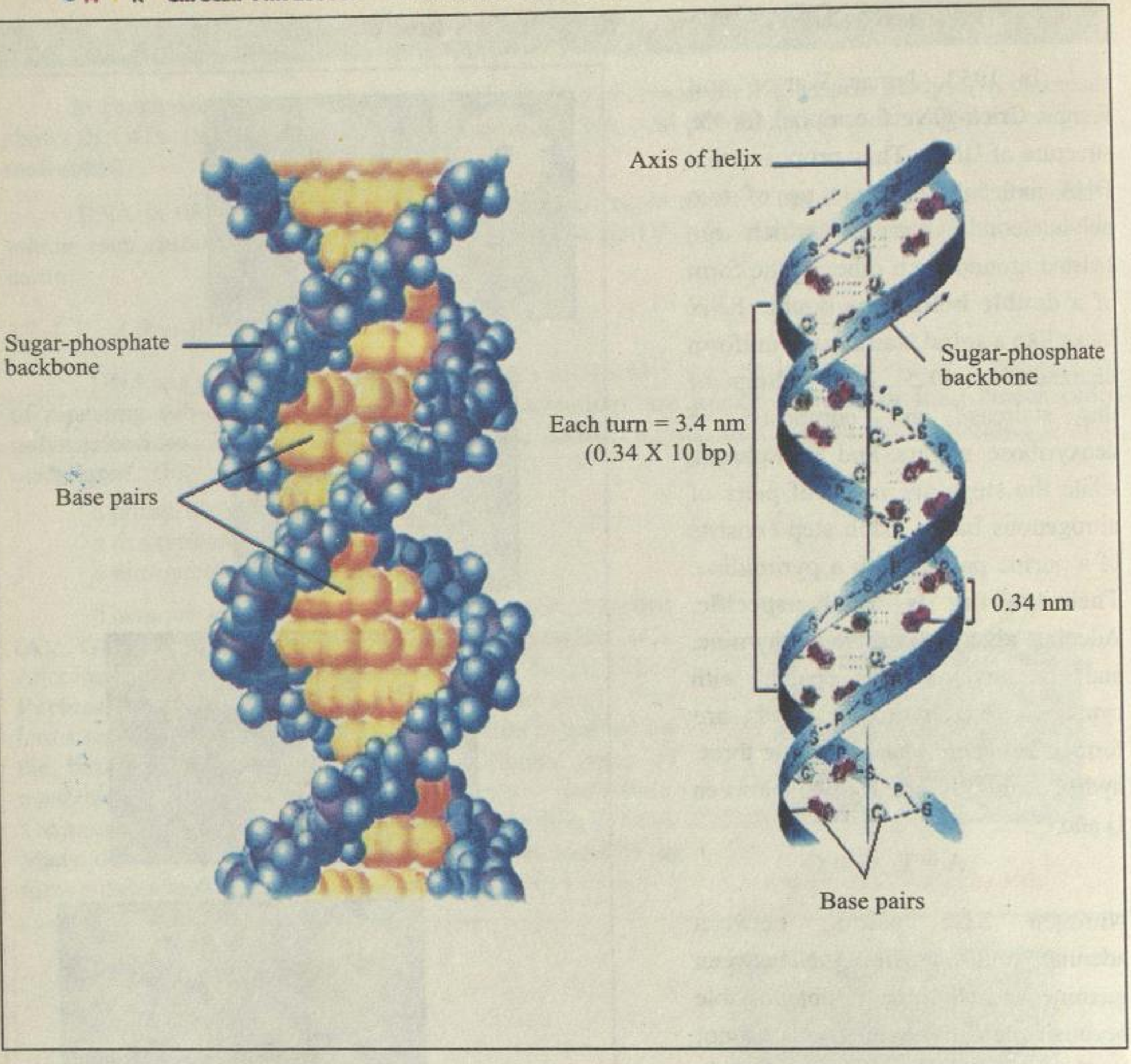

Sugar-phosphate backbone
Base pairs
Axis of helix
Sugar-phosphate backbone
Each turn = 3.4 nm
(0.34 X 10 bp)
0.34 nm
Base pairs

Fig. 17. 5 Model of DNA molecule

17.4.3 Significance of Base Sequence

The two strands of a DNA double helix are **complementary** to each other. If the sequence of bases in one strand is known, the sequence of bases in the other strand will be automatically known due to specific base-pairing. This property of the two strands of the double helix makes DNA a unique molecule best suited to store, copy and transmit genetic information from generation to generation. **Genetic information is** nothing else but this **base sequence of DNA in a linear order**. All sorts of coded biological information is stored in the form of this base sequence. **Genes are parts of DNA comprising the base sequences**. A change in the base sequence is called **point mutation,** due to which mutated gene becomes different in behaviour from its parental gene.

$$\text{CTT} \xrightarrow{\text{Point Mutation}} \text{CAT}$$

Activity No.1: Study of Base Sequence in Structure of DNA

The following is a DNA molecule (Fig 17.6). Carefully look at its base sequence on one strand and construct the complete molecule.

Many base-pair sequences in your DNA are identical to those of your parent's DNA. Despite this striking similarity, much of your DNA is different from theirs due to mutation or genetic recombination. This makes you and your DNA very unique.

DNA stores genetic information in the sequence of its bases in a linear order

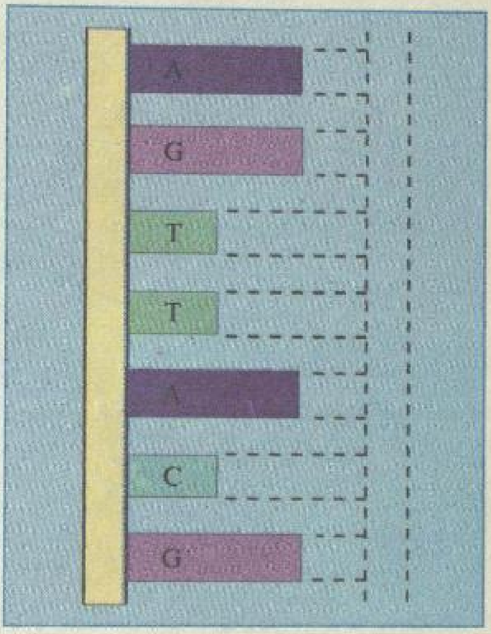


Fig 17.6 Study of base sequence in DNA

17.4.4 Replication of DNA

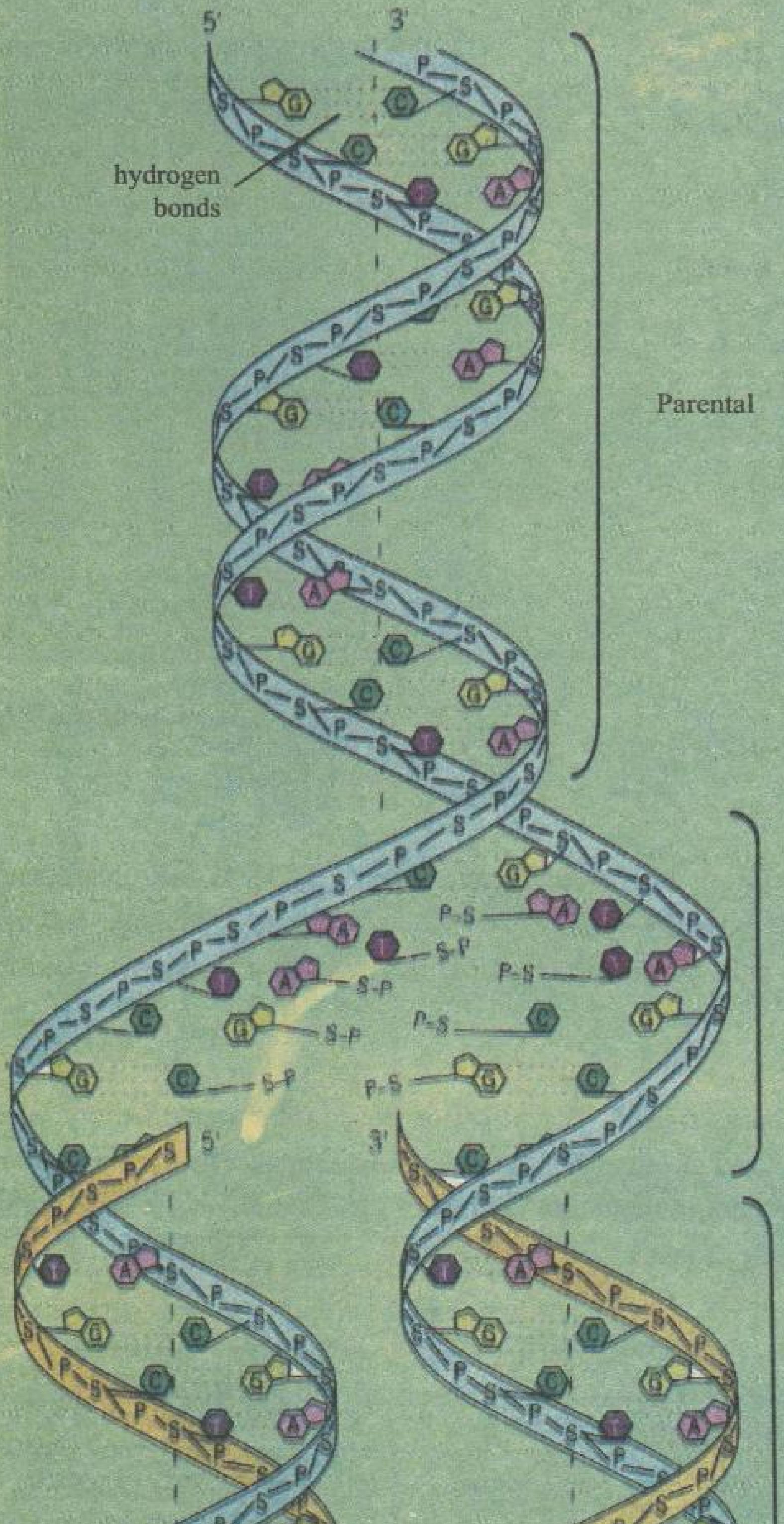
The human genome contains about 6 x 10^9 nucleotide pairs of DNA. All this genetic information must be duplicated immediately before each cell division, so that each daughter cell must have identical information like the parent cell. DNA is the heredity material only because it is capable of self- replication (Fig 17.7).

Watson and Crick proposed mechanism of DNA replication based on complementary base – pairing. The DNA molecule begins to unwind at one end. It unzips like a zipper. The hydrogen bonds between base pairs are broken, and the two complementary strands of DNA double helix separate like two halves of an open zipper. **A** separates from **T**, and **G** separates from **C**. The bases along each parental strand are exposed free. Each strand of the parent DNA now serves as **template**. Its exposed bases can be paired by fresh proper partners. All four types of deoxyribonucleotides are floating in nucleoplasm. Their bases are attracted by complementary bases of each exposed strand. The incoming nucleotides pair their complementary bases on the template.

Each daughter DNA molecule contains one old parental strand and one new strand. That is why this replication is semiconservative – half new, half old.

A complete complementary new strand is formed opposite to each old parental strand. The new strand is exactly like the one that had been separated. Thus two identical double helix molecules are formed from parental DNA molecule.

DNA polymerase enzyme helps in binding the fresh nucleotides to the template strand.


5'
3'
hydrogen bonds
Parental
5'
3'
5'
3'
5'
3'

Replication in progress Parental DNA is unzipped and new nucleotides are pairing with those in parental stands.

Replication is complete. Two identical double helix molecules (Daughter DNA) are formed.

Fig 17.7 Replication of DNA

17.5 How do Genes Function ? How is a Phenotype Produced ?

Every phenotype is based on specific biochemical molecules, e.g.; proteins. These proteins are made in the cells under the instructions of genes. Genes sit like a 'Boss' seated comfortably on chromosomes in their office – the nucleus. They get their job done in cytoplasm through their managers – RNAs.

RNA

RNA is ribonucleic acid (Fig 17.8). It is also a polynucleotide but its basic unit is ribonucleotide. A ribonucleotide consists of a phosphate group, **Ribose** sugar and a nitrogenous base. Its four bases are adenine **(A)**, guanine **(G)**, cytosine **(C)** and **Uracil (U)**. DNA controls synthesis of RNA.

RNA is slightly different from DNA:

1. RNA has ribose instead of deoxyribose
2. RNA has uracil instead of thymine
3. RNA is a single polynucleotide strand, but DNA is made up of two polynucleotide strands.
4. RNA is found throughout the cell but DNA is concentrated in the nucleus.
5. RNA is of three types: messenger RNA (mRNA) transfer RNA (tRNA) and ribosomal RNA (rRNA) but DNA has no such types.

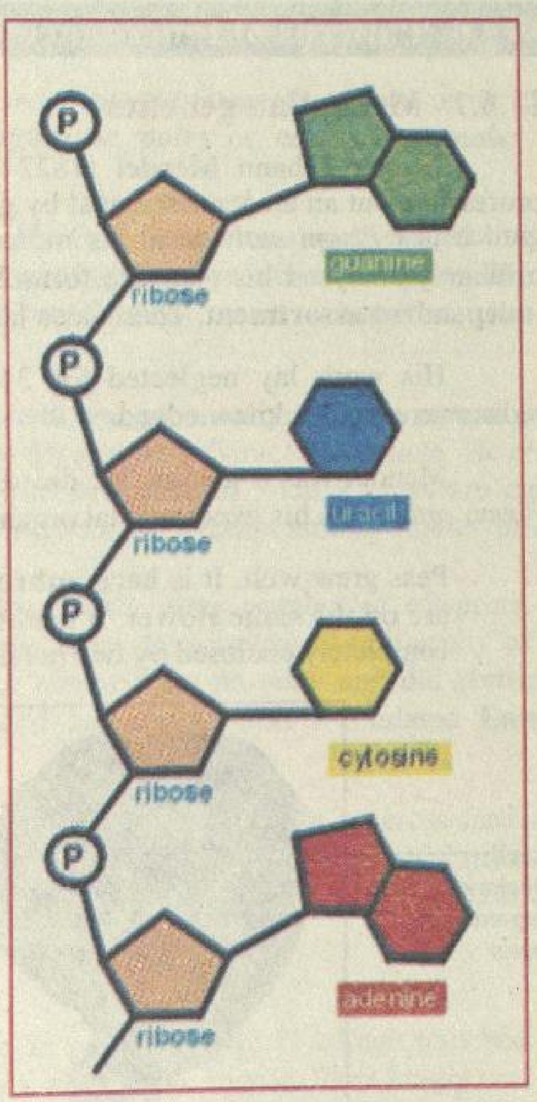


Fig. 17.8 Structure of RNA

A gene expresses itself in two steps (Fig 17.9):

1. **Transcription:** The coded information in DNA, which is there in the form of base sequence, is copied into the base sequence of messenger RNA.

Copying of DNA-encoded information into RNA-encoded information is called transcription. Translation is decoding of mRNA information into a sequence of amino acid in a protein.

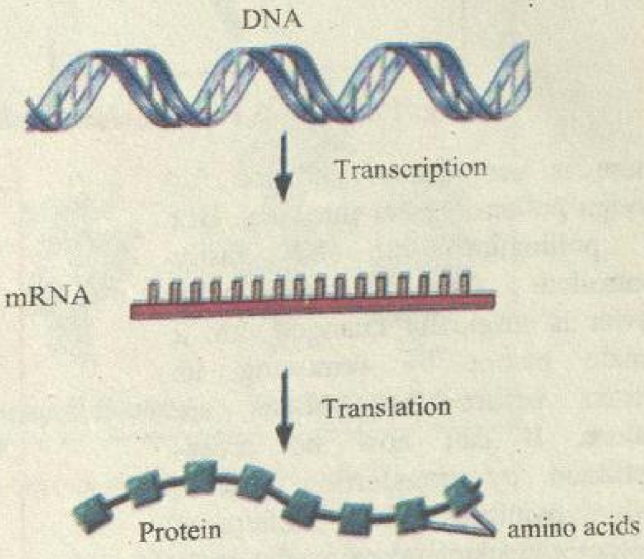


Fig 17.9 Genetic Information flows from DNA to Protein through mRNA

2. **Translation:** The messenger RNA's message is for the protein synthesis. Its base sequence is translated into a sequence of amino acids of a particular protein.

17.6 Patterns of Inheritance

17.6.1 Mendelian genetics

Gregor Johann Mendel (1822-1884) is called "father of genetics". He was a priest by profession, but an amateur scientist by genius. In 1854 he began his famous breeding experiments on garden pea *Pisum sativum* in his monastery garden. Mendel performed series of experiments and brilliantly analysed his data. He formulated two laws of heredity; **law of segregation**, and **law of independent assortment**. These laws laid the foundation of **classical genetics** in 1866.

His work lay neglected for 34 years. In 1900, 16 years after his death, his work was rediscovered and acknowledged.

Mendel was a genius. He did differently from other workers of his time. He wisely chose *Pisum sativum* as his experimental organism because he knew its advantages:

1. Peas grew well. It is **hermaphrodite** (⚥) because both of its male and female sex organs are on the same flower. It is normally **self-fertilizing** because its stamens and carpel are completely enclosed by two petals, which fuse to form a **keel** around them (Fig 17.10 a,b).

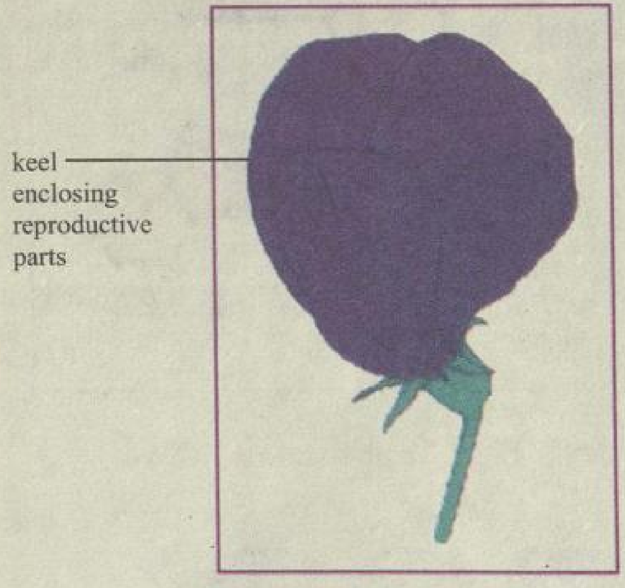


Fig. 17.10(a) A Pea Flower

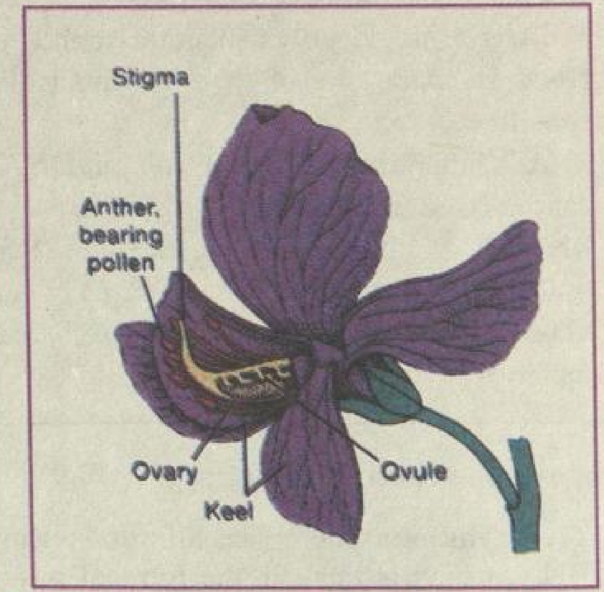


Fig 17.10(b): A pea flower with the keel opened to expose its reproductive parts

There is very remote chance for foreign pollen to enter into keel. But its pollination can be easily controlled. The hermaphrodite flower is surgically changed into a female parent by removing its anthers before the pollens are mature. It can now be **cross-fertilized** by transferring pollens with a paintbrush from anthers of another pea plant taken as the male parent (Fig. 17.10c).

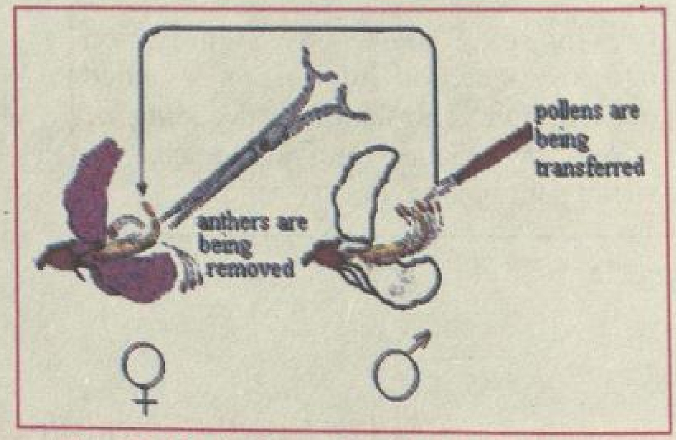


Fig 17.10(c): Cross fertilization of Pea

2. Pea produces a **large number of fertile seeds** within a relatively short growing season. As the time gap between generations is short, many generations can be easily raised within a short time.

3. Pea has many sharply distinct traits. Each trait has two clear-cut alternative forms or varieties. Mendel called such alternative varieties as **antagonistic pairs** or **contrasting pairs**. He settled on seven such pairs for his study.

Mendel's experimental approach was **systematic**. He first isolated and perpetuated lines of pea that **bred true**. Self-fertilization within such **pure-breeding lines** produced offspring like the parents. After establishing 14 true-breeding lines or varieties of seven characters, he did **hybridization** or cross-fertilization.

Hybrid is an organism that arises from mating between two genetically different parents.

He worked with patience. First he did hybridization for just one character at a time. He cross-fertilized plants differing in one contrasting pair only. The offspring of such a cross are called **monohybrids**. Then he made **monohybrid cross** by allowing self-fertilization among monohybrids.

He worked with large number of plants to produce fairly large number of offspring. He worked on each of the seven pairs of traits separately. His large data increased uniformity of the result and reduced the chance of individual variation. He counted the progeny and did **statistical analysis**. It provided him clear-cut ratios. He compared his results and formulated **Law of segregation**.

Then he studied inheritance of two traits at a time. He made **Dihybrids** by cross-fertilizing plants differing in two contrasting pairs. Then he made **dihybrid cross** by allowing self-fertilization among dihybrids. He counted their progeny and did analysis of his results. He got clear-cut ratio even now. He formulated **Law of independent assortment**.

17.6.2 Seven contrasting pairs of traits

Mendel chose to work on seven characters or traits in pea(Figure 17.11). Each trait had two sharply distinct varieties e.g.; seed shape had a round and a wrinkled phenotype. Plant height was either tall or short. Seed colour could be yellow or green. Mendel called them **contrasting pairs of traits**. Each of this variety bred true generation after generation.

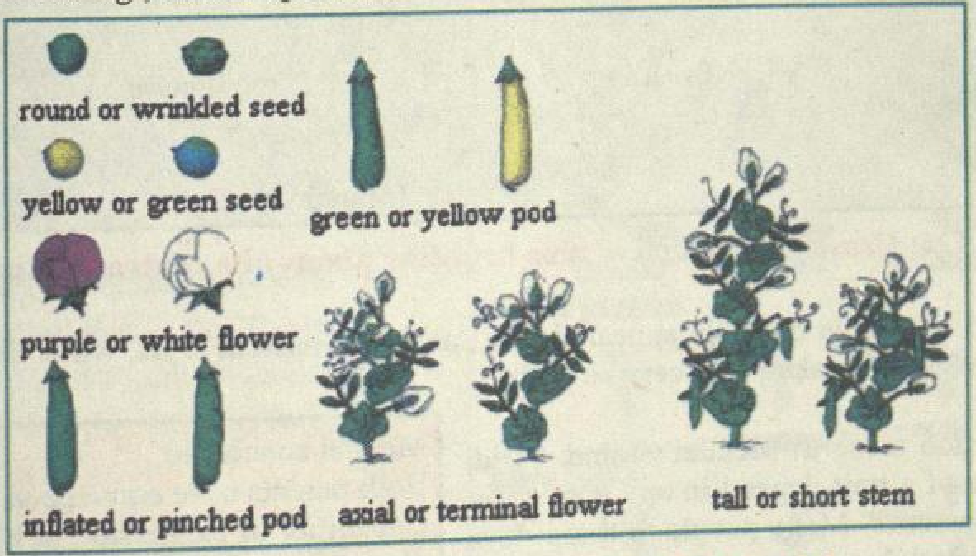
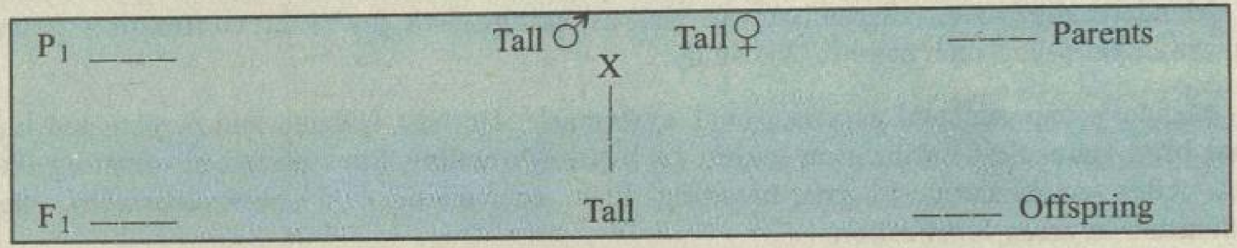


Fig 17.11: The seven character differences studied by Mendel

A **true breeding variety** upon self-fertilization always produces offspring identical to the parents. e.g. a true breeding "tall" plant produces only "tall" offspring (Fig 17.12). Similarly a true breeding "short" produces only "short" offspring. He established 14 true breeding varieties of seven traits.



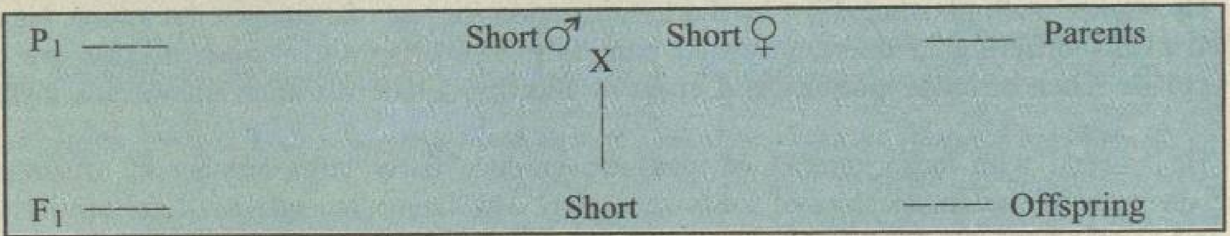


Fig 17.12: True breeding plants.

17.6.3 Cross-fertilization

Mendel cross-fertilized a true breeding "tall" male plant with a true breeding "short" female (Fig.17.13a). He called this **first parental generation (P_1)**. Their offspring were called **F_1** or **first filial generation**. Filial means progeny. All the offspring of F_1 were tall like one of the parents. Short phenotype could not appear. Tall dominated short. Its dominance was complete because no offspring intermediate in size between two parents was found. There was no mixing or blending.

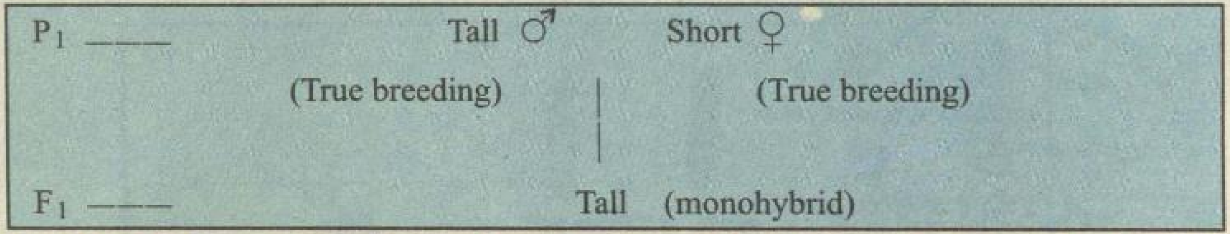


Fig. 17.13a: Cross fertilization of true breeding plants of a contrasting pair of trait.

Mendel called the trait that appeared in F_1 as the **dominant trait**; while the trait, which was hidden, suppressed or masked as **recessive trait**.

Mendel concluded:
Both parents have equal genetic contribution.
Capability of expression in F1 is a trait's own characteristic. It has nothing to do with sex of the contributor.

A question arose in Mendel's mind. "Did the appearance of a trait depend in any way upon the sex of the parent?" Many people in those days believed in Aristotle's misconception that only the male parent contributed most to an offspring's inherited characters. The female parent just served to nourish. In order to test it, Mendel made a **reciprocal cross** by reversing sexes of P_1 (Fig 17.13b).

P_1 —— Tall ♀ (True breeding) X Short ♂ (True breeding)

|

F_1 —— Tall (monohybrid)

Fig 17.13b: Reciprocal cross

The result was same. Again all F_1 monohybrids were tall. It happened for all the seven contrasting pairs of traits (Fig 17.14).

Monohybrid cross: It is a cross between two monohybrids. Mendel self-fertilized F_1 tall plants to raise F_2 progeny. Surprisingly ¾ of F_2 were tall and ¼ short. A clear cut 3:1 ratio was found. The reappearance of short in F_2 indicated that this phenotype though not expressed in F_1, did exist in some masked form (Fig 17.15). The dominant trait might have temporarily masked its expression, but it could not change or modify its determining nature.

Reappearance of recessive trait in F_2 disproves any blending in F_1.

F_1 tall was actually very different from P_1 tall. How? Self-fertilization of P_1 tall produced 100% tall offspring, but self-fertilization of F_1 tall gave 75% tall and 25% short progeny. F_1 tall was not true breeding rather it was a **monohybrid**.

Mendel got the same results and similar 3 : 1 ratio in offspring of monohybrid crosses for all the seven contrasting pairs of traits.

$$\begin{array}{c} F_2 \times F_2 \\ \downarrow \\ F_3 \end{array}$$

Mendel also raised F_3 generation by self-fertilizing F_2 plants. He found that 1/3 of F_2 tall produced only tall, while 2/3 of F_2 tall produced both tall and short in 3: 1 ratio. But F_2 short produced only short.

Can you say that 1/3 of F_2 tall were like P_1 tall and 2/3 of F_2 tall were like F_1 tall?

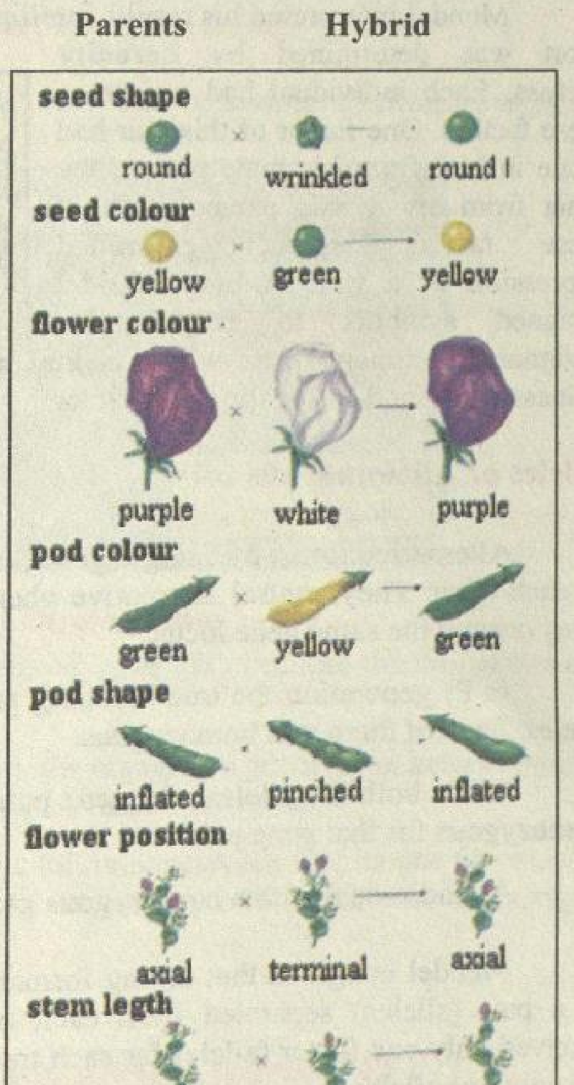

Parents
Hybrid
seed shape
round
wrinkled
round
seed colour
yellow
green
yellow
flower colour
purple
white
purple
pod colour
green
yellow
green
pod shape
inflated
pinched
inflated
flower position
axial
terminal
axial
stem legth
tall
short
tall

Fig 17.14 Parents with antagonistic traits produced hybrids showing only dominant trait.

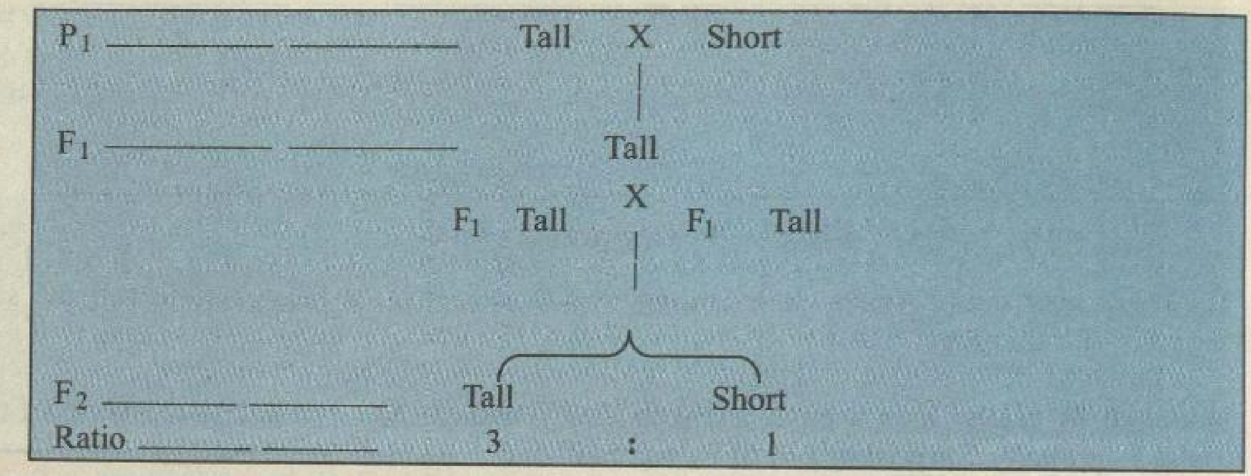


Fig 17.15: Offspring of monohybrid cross in ratio 3:1

17.6.4 Mendel's Interpretations

Mendel interpreted his results intelligently. He imagined that contrasting form of a trait, tall or short was determined by **heredity factors**. Each individual had a **pair** of these factors. One factor of this pair had come in him from his male parent, the other from his female parent. Both of these factors together controlled expression of a trait in him. Mendel assigned symbols to factors. He designated dominant factor with a capital letter and recessive factor with a small letter, e.g. 'T' for tallness factor and 't' for shortness factor.

What are Mendel's factors? For him these were discrete physical units of inheritance. Johanson coined the term 'gene', and people started calling them genes. Today for us these factors are parts of DNA, the base sequences that carry the biological information to determine a trait. Mendel's factors are alleles of genes.

Alleles or Allelomorphs

Alternative forms of a single gene are called alleles or allelomorphs. e.g. 'T' and 't' are alleles of each other. They control alternative phenotypes of a trait. They are members of same gene pair. They occupy the same gene locus.

In P_1 generation the true breeding tall plant carried 'TT' alleles while short plant carried 'tt' alleles. Each of them was homozygous.

When both the alleles of a gene pair in an organism are same, the organism's genotype is **homozygous** for that gene pair.

An individual with a homozygous genotype is a **homozygote**.

Mendel imagined that during formation of gametes, the factors of a pair (alleles) separated from each other so that each gamete received only one factor (allele) for each trait. Each gamete was "pure" for only one allele.

A homozygote forms all gametes of one type.

Distribution of alleles into gametes was at random. Every gamete had equal chance of getting one allele or the other of a pair. So half the gametes had one allele, and the other half carried the other allele. At fertilization male gamete with one factor (T) united at random with female gamete carrying its factor (t) to restore the complete set of two factors (Tt) for the trait in zygote (Fig 17.16a).

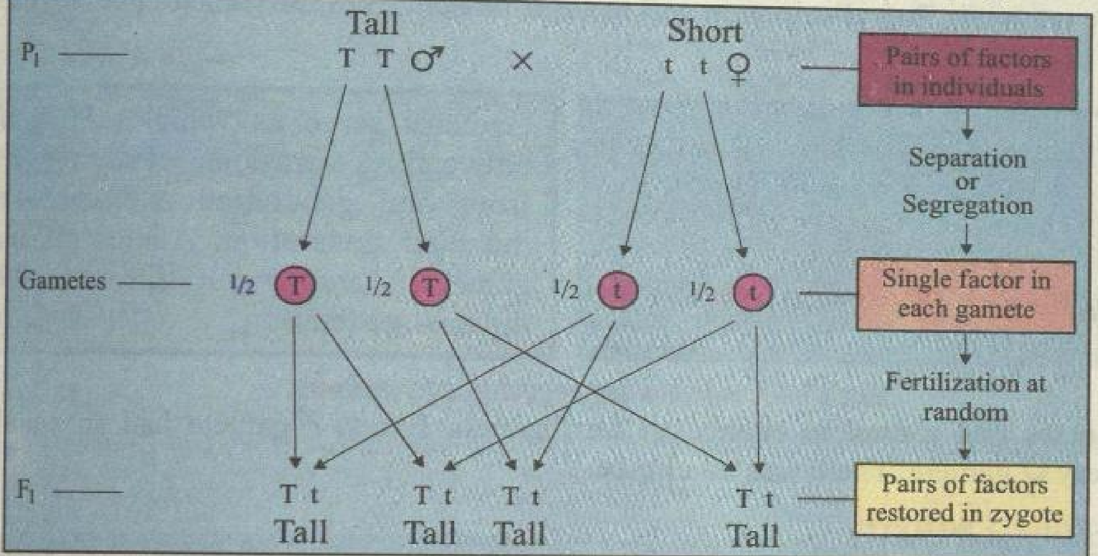

Tall
T T ♂
×
Short
t t ♀
P₁
Pairs of factors in individuals
Separation or Segregation
Gametes
1/2 T
1/2 T
1/2 t
1/2 t
Single factor in each gamete
Fertilization at random
F₁
T t Tall
T t Tall
T t Tall
T t Tall
Pairs of factors restored in zygote

Fig 17.16 (a) : Transmission of Mendelian factors

Doesn't the mode of transmission of Mendelian factors look like behaviour of chromosomes (Fig 17.16b)?

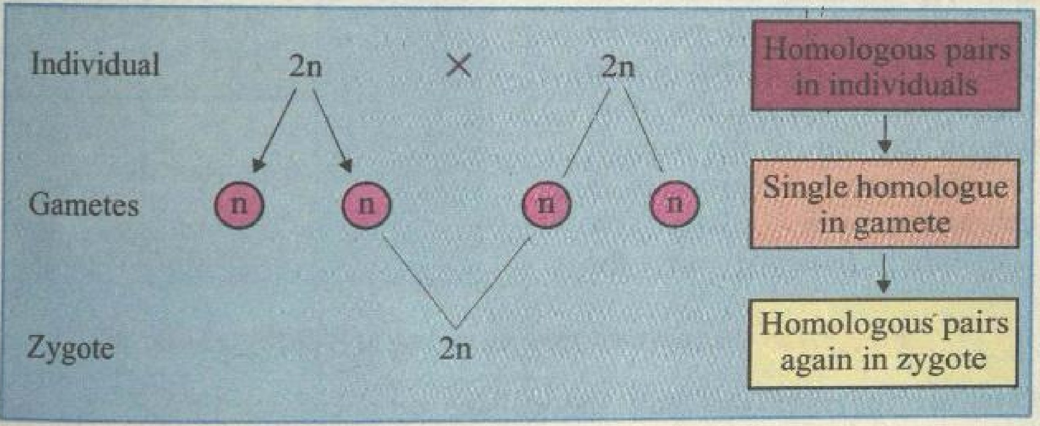

Individual
2n
×
2n
Homologous pairs in individuals
Gametes
n
n
n
n
Single homologue in gamete
Zygote
2n
Homologous pairs again in zygote

Fig 17.16b: Behaviour of chromosomes

F_1 offspring developing from the zygote was heterozygous 'Tt', because the two alleles of its gene pair were different.

When the alleles of a gene pair are different in an organism, the organism's genotype is **heterozygous** for that gene pair. An individual with a heterozygous genotype is a **heterozygote**.

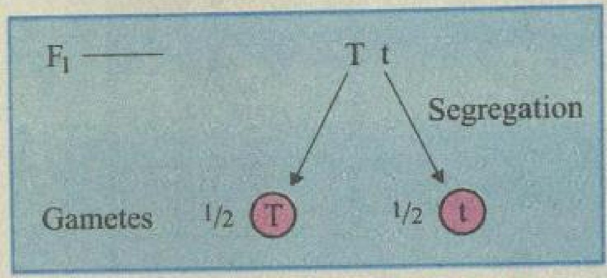
F_1 offspring was a monohybrid for the trait. It was tall in appearance like its one parent, same phenotype; but actually very different in genetic make up or genotype. Its parent was homozygous tall, it was heterozygous tall.

17.6.5 How did contrasting factors behave when present together in F_1?

Dominance only suppresses a recessive gene's expression. It does not affect its nature.

The two different factors (alleles) in F_1 stayed together and coexisted side by side without interfering or intermingling each other's nature. One (T) became dominant, the other (t) recessive, but their trait determinative natures were not modified.

But at the time of gamete formation those two alleles 'T' and 't' separated or **segregated** from each other in a manner that only one allele went into one gamete. Each gamete got only one of the two alleles, not both. Their distribution was again at random. Half the gametes got 'T', the other half got 't' (Fig 17.17).



Gametes serve as vehicles for inheritance between generations. They pick alleles from one generation and carry them to the next generation. Alleles sit quietly in gametes. These do not express till they reach the next generation.

Fig 17.17: Alleles segregating at random.

Gametes had a random chance of fertilization. Every ♂ gamete had an equal chance to fertilize every ♀ gamete. There was no choice.

17.6.6 Punnett square

Let us visualize self-fertilization of F_1 with the help of Punnett square (Fig 17.18). It is also called checkerboard. Punnett was a British mathematician who introduced it. It is a simple method for tracking the kind of gametes produced as well as all possible combinations at fertilization. Gametes of one parent are arranged on the top, and the other parent's gametes on the side of the square. Each block of the square represents a possible combination of alleles at fertilization, i.e. the genotype of the offspring.

Female Gametes	Male Gametes 1/2T	Male Gametes 1/2t
1/2T	1/4TT	1/4Tt
1/2t	1/4Tt	1/4tt

Fig 17.18: Punnett square showing self-fertilization of F_1 to produce F_2.

Punnett square indicates that half the pollens produced by F_1 had 'T', and half had 't'. similarly half the eggs produced by F_1 had 'T', and half the eggs had 't'.

At fertilization ¼ of F_2 progeny would have been 'TT' (homozygous tall), ¼ + ¼ = ½ 'Tt' (heterozygous tall), and ¼ 'tt' (short).

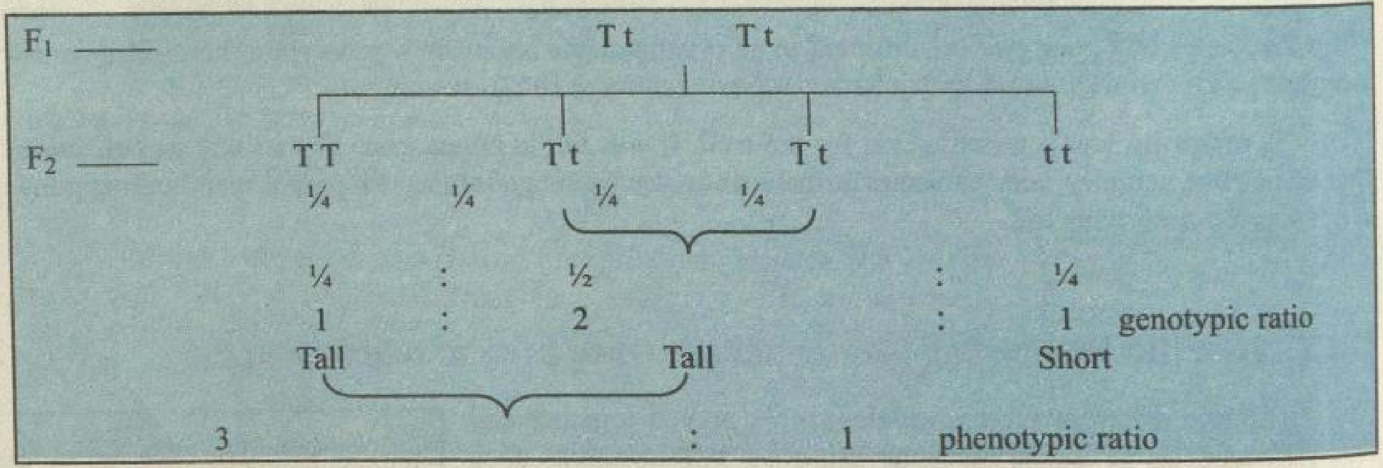


Fig. 17.19Monohybrid cross showing genotypic and phenotypic ratios among offspring

What Mendel really observed in F_2 was phenotypic ratio 3 : 1. By carefully looking at genotypic ratio 1 : 2 : 1 we can easily understand and explain Mendel's data of F_2 (Fig 17.19).

Mendel's law of segregation

"The two coexisting alleles of an individual for each trait segregate (separate) during gamete formation so that each gamete gets only one of the two alleles. Alleles again unite at random fertilization of gametes."

Mendel's concept of gene, and his law of segregation can be applied to all sexually reproducing organisms.

17.6.7 Test cross

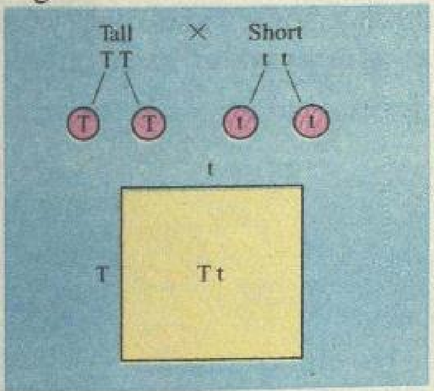
Mendel devised test cross to find out genotype of an individual who had dominant phenotype, e.g. tall.

Test cross is a mating in which an individual showing a dominant phenotype is crossed with an individual showing its recessive phenotype (Fig 17.20).

A phenotypically tall individual could be homozygous (TT) or heterozygous (Tt).

Case I

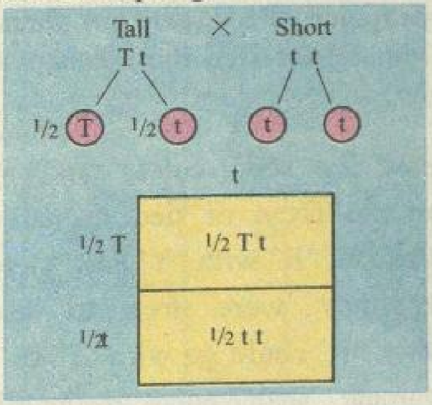
If it is homozygous tall (TT), it will form all gametes with a 'T' allele. Short is always homozygous recessive. It will form all gametes with a 't' allele. Fertilization will result in 100% tall offspring.



Result:
All tall offspring
The phenotypically dominant individual is homozygous.

Case II

If the tall is heterozygous (Tt), it will form half the gametes with a 'T' and half with a 't' allele. Short will form only 't' type of gametes. Fertilization will result into 50% tall and 50% short offspring.



Result:
½ Tt = tall , ½ tt = short offspring
The phenotypically dominant individual is heterozygous.

Fig 17.20: Test cross of a tall plant.

17.6.8 Inheritance of two traits simultaneously

After thoroughly studying single trait inheritance Mendel decided to go for two traits at a time, e.g. seed shape and seed colour. Seed shape had two distinct phenotypes: seed could be round or wrinkled. Seed colour was another trait. It also had two phenotypes, yellow or green.

Mendel took true breeding round and yellow seed plants and crossed them to true breeding wrinkled and green seed plants. All the F_1 offspring were round and yellow seeded due to dominance. He allowed these F_1 **dihybrids** to self-fertilize. The result of this **dihybrid cross** was surprising for him. F_2 progeny consisted of not only the two **parental combinations** (round yellow, and wrinkled green) but also two new **phenotypic combinations** (round green and wrinkled yellow). He got 9 : 3 : 3 : 1 ratio among F_2 (Fig 17.21).

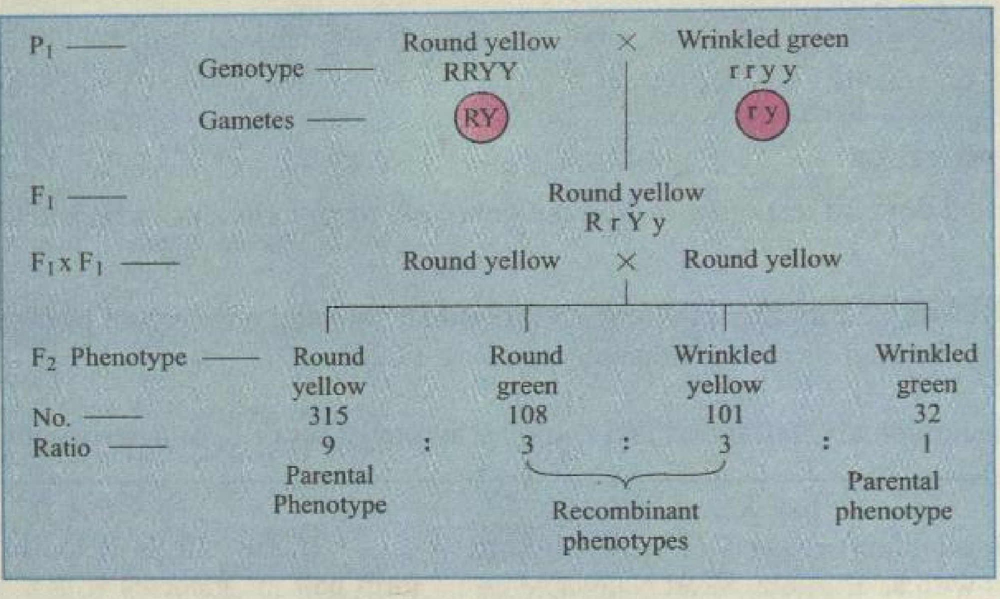

P₁ ——
Round yellow
×
Wrinkled green
Genotype ——
RRYY
rryy
Gametes ——
RY
ry
F₁ ——
Round yellow
RrYy
F₁ x F₁ ——
Round yellow
×
Round yellow
F₂ Phenotype ——
Round yellow
Round green
Wrinkled yellow
Wrinkled green
No. ——
315
108
101
32
Ratio ——
9 : 3 : 3 : 1
Parental Phenotype
Recombinant phenotypes
Parental phenotype

Fig 17.21: Inheritance of two traits simultaneously.

Appearance of recombinant phenotypes in F_2 indicated that some "shuffling" of alleles had occurred. Mendel inferred the mechanism of this shuffling as **independent assortment of alleles** into gametes.

Alleles for seed colour and seed shape were not fixed or tied in parental combinations i.e., 'R' with 'Y' and 'r' with 'y'; rather they were free to assort independently, 'R' could go with 'Y' or 'y' in any gamete with equal probability. Similarly 'r' could go with 'Y' or 'y' in any gamete with equal chance. Four kinds of gametes were produced in equal number, with a perfect ratio 1 : 1 : 1 : 1 (Fig 17.22).

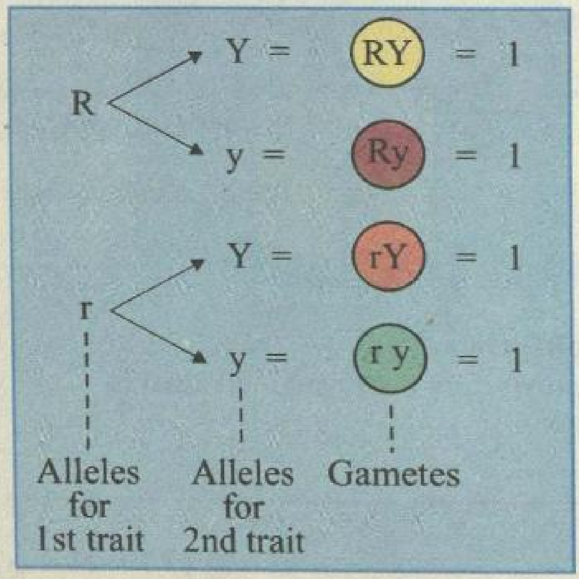

R
Y =
RY
= 1
y =
Ry
= 1
r
Y =
rY
= 1
y =
ry
= 1
Alleles for 1st trait
Alleles for 2nd trait
Gametes

Fig 17.22: Independent assortment of alleles into gametes.

Random fertilization of these gametes would produce 9 : 3 : 3 : 1 ratio (Fig 17.23 a,b)

[illegible]

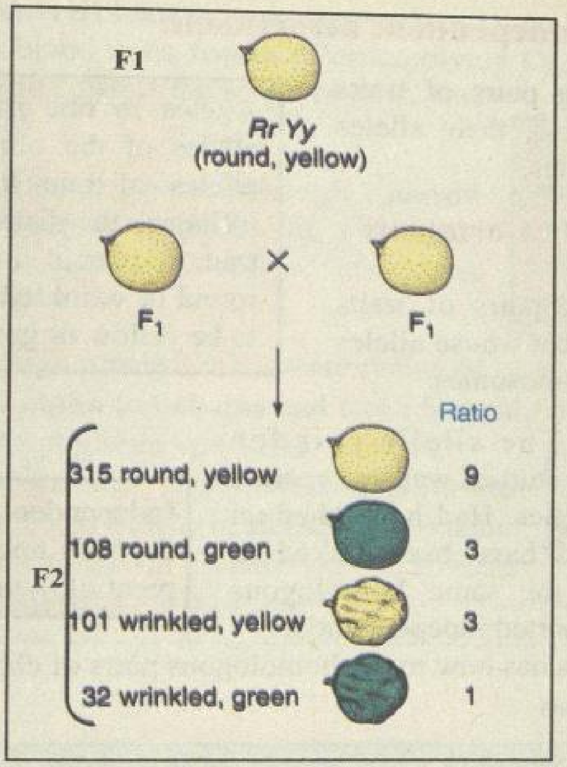

F1
Rr Yy
(round, yellow)
F1
×
F1
Ratio
F2
315 round, yellow
9
108 round, green
3
101 wrinkled, yellow
3
32 wrinkled, green
1

Fig 17.23a: The F_2 generation produced from a dihybrid cross.

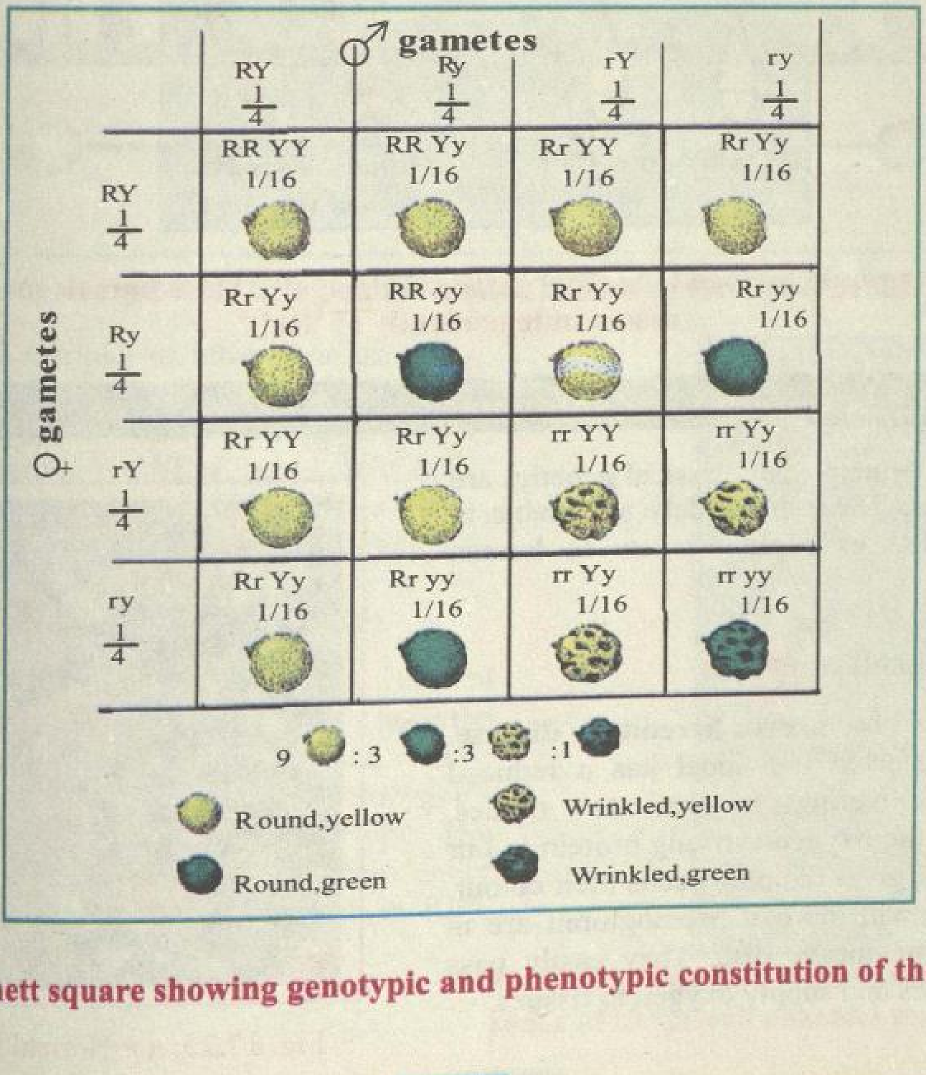

♂ gametes
RY 1/4
Ry 1/4
rY 1/4
ry 1/4
♀ gametes
RY 1/4
Ry 1/4
rY 1/4
ry 1/4
RR YY 1/16
RR Yy 1/16
Rr YY 1/16
Rr Yy 1/16
Rr Yy 1/16
RR yy 1/16
Rr Yy 1/16
Rr yy 1/16
Rr YY 1/16
Rr Yy 1/16
rr YY 1/16
rr Yy 1/16
Rr Yy 1/16
Rr yy 1/16
rr Yy 1/16
rr yy 1/16
9 : 3 : 3 : 1
Round,yellow
Wrinkled,yellow
Round,green
Wrinkled,green

Fig. 17.23b: Punnett square showing genotypic and phenotypic constitution of the F_2 generation

17.6.9 Mendel's law of independent assortment:

"When two contrasting pairs of traits are followed in the same cross, their alleles assort independently into gametes.

Alleles in one pair inherit independently of alleles of the other pair. The distribution of alleles of one trait into gametes does not influence the distribution of alleles of the other trait. It means that chance for a plant to be round or wrinkled is independent of its chance to be yellow or green.

Conditions for independent assortment:

Only those contrasting pairs of traits can show independent assortment whose alleles are riding nonhomologous chromosomes.

Mendel was lucky. The allelic pair for each of the seven characters he studied was on separate homologous pair of chromosomes. Had he studied an eighth trait, its alleles would have been linked to alleles of any other trait on the same homologous pair, and could have never assorted independently. Can you guess why? Recall pea has how many homologous pairs of chromosomes (Fig 17.24).

Independent assortment of genes depends upon independent assort - ment of their chromosomes.

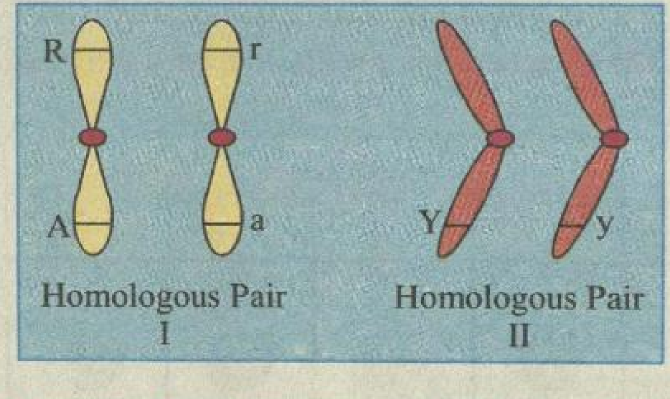


Fig 17.24: What would happen if another gene pair 'Aa' also rides homologous pair I? Can it assort independently of 'Rr' ?

17.7 Mendel's law and we the humans

Mendel's principles of classical genetics are fundamental laws. These are widely applicable to all organisms. Let us apply his law to human genetics.

17.7.1 Sickle-cell anaemia

Sickle-cell anaemia is a **hereditary disease**. The blood of affected individual has a reduced capacity of delivering oxygen to tissues. Haemoglobin is the oxygen-carrying protein in our red blood cells. It gives red blood cells their colour. Red blood cells with normal haemoglobin are in the shape of a biconcave disc. They easily pass through capillaries and supply oxygen to tissues.

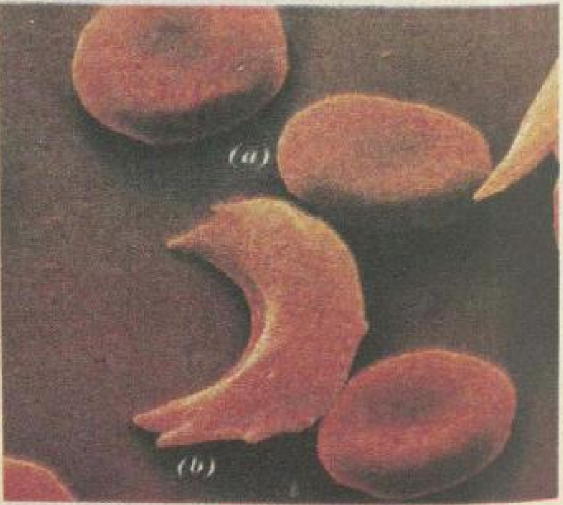


Fig. 17.25: a = Normal RBC, b = Sickle-

Red blood cells with sickle-cell haemoglobin appear normal so long as oxygen is plentiful. As the oxygen level drops when blood exits tissues after supplying O_2, this haemoglobin forms insoluble fibrous strands. These strands distort the shape of RBC into long thin sickles (Fig 17.25).

Distorted cells cannot pass through narrow capillaries. So capillaries become clogged. The tissues are starved for oxygen. Sickle-cells may rupture and cause anaemia.

A hereditary disease is a body malfunction caused by a gene. It cannot be cured unless the malfunctioning gene is repaired or replaced by a normal one.

Haemoglobin is a large protein. It has four chains of amino acids; two identical **alpha (α) chains** and two identical **beta (β) chains**. The alpha chains of normal and sickle-cell haemoglobin are alike, but their -chains differ by a single amino acid. The amino acid **glutamic acid** at 6th position is replaced by **valine** in sickle-cell -chain. The -chain of normal haemoglobin is encoded by a gene called human -globin gene (HbA) Fig. (17.26).

Anaemia is a condition of blood with lack of red corpuscles.

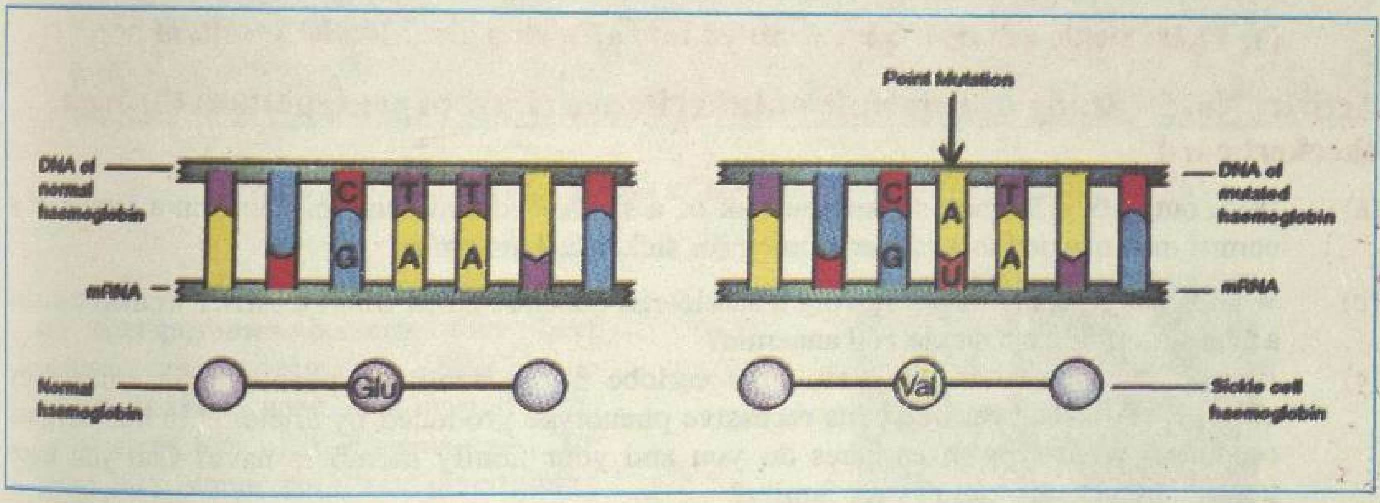


Fig 17.26: The point mutation causes sickle-cell anaemia.

The DNA triplet of HbA gene encoding for glutamic acid is CTT. A point mutation changes just the middle base of the triplet from T to A. As it becomes CAT a new allele HbS emerges. CAT encodes for valine. So, the allele for normal haemoglobin is HbA and allele for sickle-cell haemoglobin is HbS. These are present on chromosome No:11 (Fig 17.27).

Individuals homozygous for normal haemoglobin are HbA/HbA. They do not have the disease. Homozygotes for sickle-cell allele HbS/HbS have the disease. Heterozygotes HbA/HbS are called **sickle-cell carriers**. The carriers show no symptoms of the disease under normal circumstances. Only 1% of their RBC becomes sickle shaped.

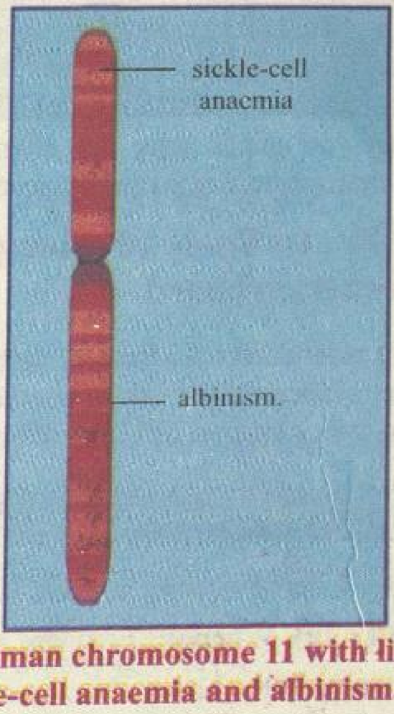


Fig 17.27: Human chromosome 11 with linked genes of sickle-cell anaemia and albinism.

It is an autosomal recessive trait (Fig 17.28). If a normal woman (HbA/HbA) marries a sickle-cell anaemic man (HbS/HbS), all their children will be carrier (HbA/HbS).

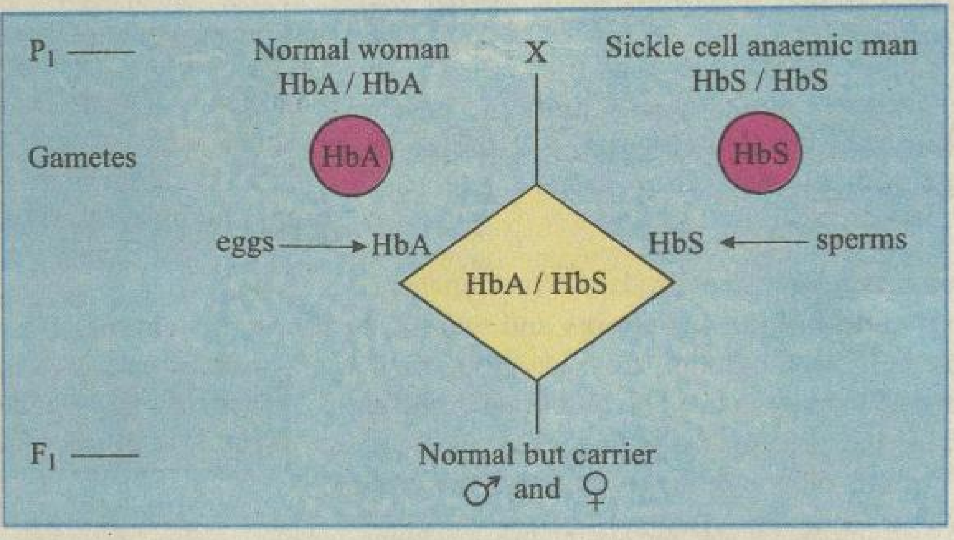


Fig 17.28: Sickle-cell trait is transmitted into offspring like Mendel's traits of pea.

Activity No. 5: Study of Principle of inheritance (Law of segregation) through checkerboard

(a) Work out with a Punnett square the risk of a sickle-cell anaemic childbirth in a family of a normal man married to a carrier woman for sickle-cell anaemia.

(b) What is the probable risk of having a sickle-cell anaemic child when a carrier woman marries a man suffering from sickle-cell anaemia?

(c) Earlobe is a normal human trait. Free earlobe is the dominant phenotype determined by allele 'E'. Attached earlobe is its recessive phenotype produced by allele 'e' in homozygous condition. What type of earlobes do you and your family members have? Can you trace transmission of this trait in your family?

17.7.2 Diabetes Mellitus

It is a **hereditary disease** caused by a recessive allele 'd' in homozygous condition. Diabetics are unable to use glucose in their body metabolism. They pass glucose in their urine. Normal individuals have dominant allele 'D'. Their urine is without glucose.

Can you guess why the chances of diabetes in children increase when both parents are diabetics, than when one parent is normal but the other diabetic?

Activity No. 6: Study of principle of inheritance (Law of independent assortment) through checkerboard.

If a man suffering from diabetes but homozygous normal for haemoglobin marries a woman homozygous normal for sugar metabolism but suffering from sickle-cell anaemia, what are the chances in their children of being diabetic and sickle-cell anaemic at a time?

17.8 Sex determination in Man

As you have already studied, we humans have 46 chromosomes in the form of 23 homologous pairs (Fig 17.29). When we compare karyotype of a human male with female, we notice that 22 pairs are common in both. These chromosomes are **autosomes**. But the 23rd pair is very different in males and females: A woman has two similar chromosomes in her 23^{rd} pair. These are called X-chromosomes. She is XX.

The chromosomes of 23^{rd} pair of a man are morphologically different from each other. One is X-chromosome while the other much shorter is Y-chromosome. He is XY.

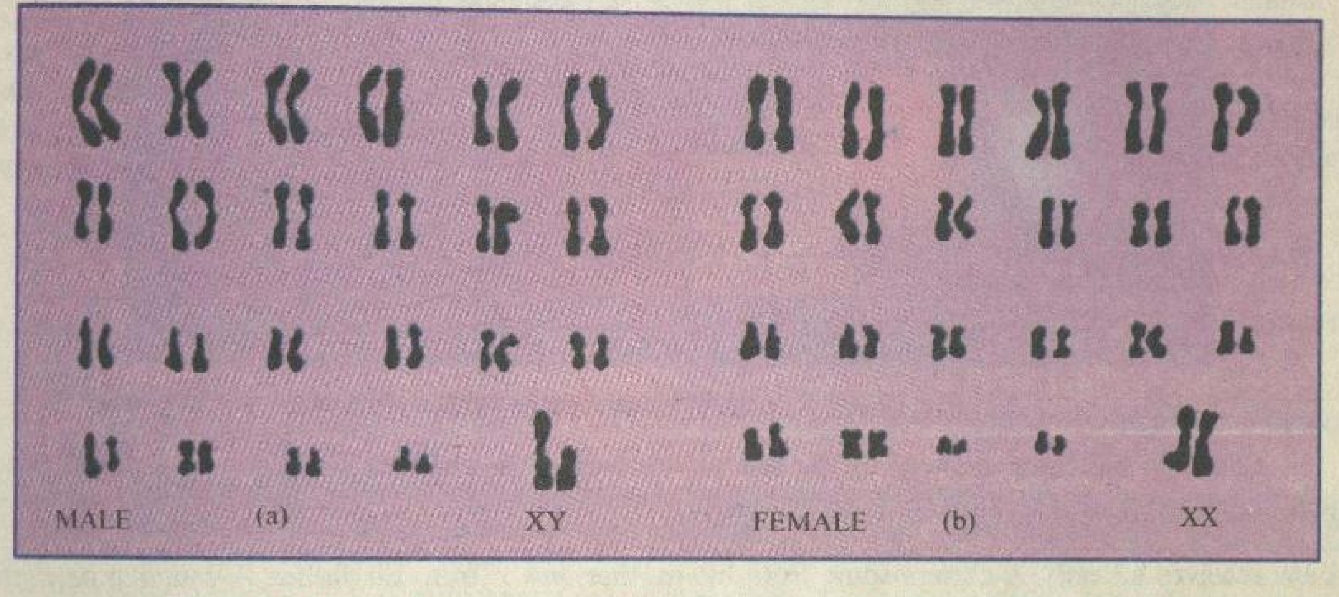


Fig: 17.29 The chromosomes of the human male (a) and female (b)

X and Y chromosomes are called **sex chromosomes** because they have genes for sex determination. 'SRY' is the male determining gene. It is located at the tip of short arm of Y-chromosomes. Its name SRY stands for "sex determining regions of Y" (Fig17.30).

Autosomes do not carry any sex-determining gene. All chromosomes other than sex chromosomes are called autosomes. The genes on autosomes determine autosomal traits.

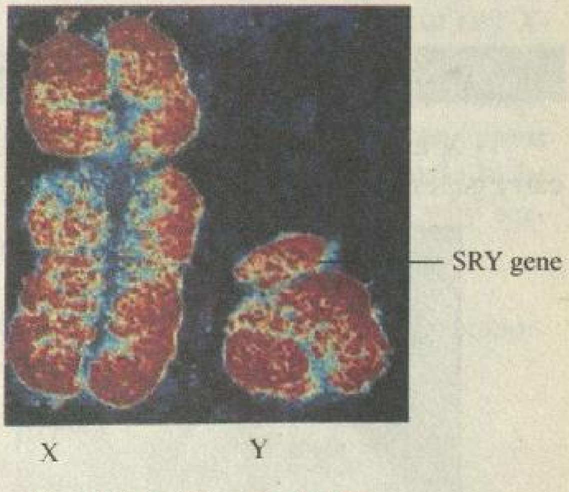
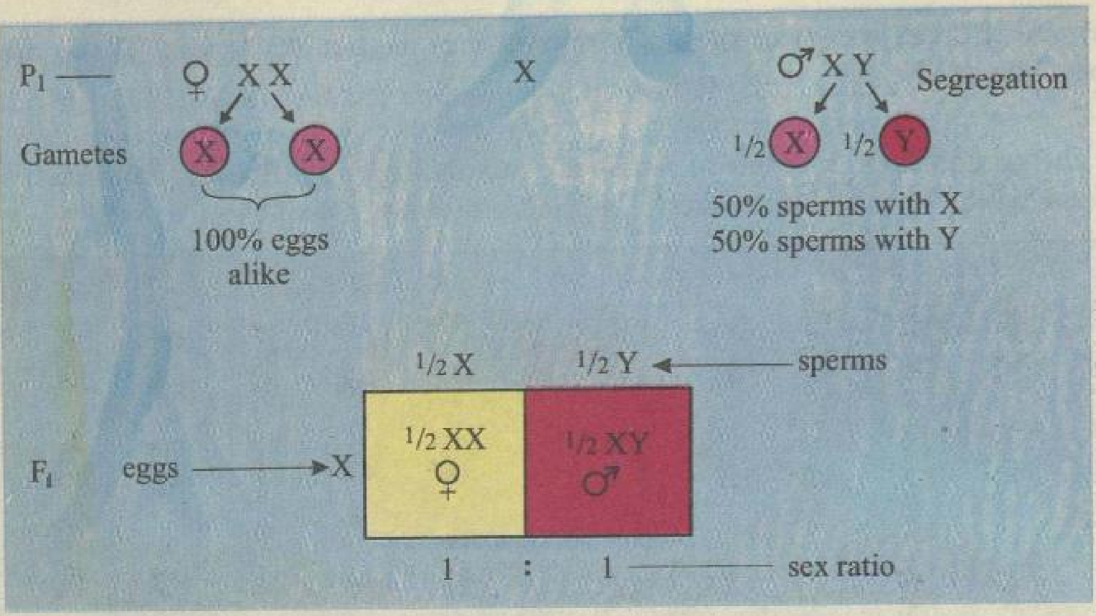


Fig: 17.30 The X and Y chromosomes of man.

When chromosomes segregate at meiosis, each homologue of the 23^{rd} pair also moves in one gamete. A woman being XX produces eggs, each with an X-chromosome. As all her eggs are alike she is **homogametic**. A man is XY. He produces two types of sperms, half carrying X chromosome, the other half carrying Y. He is **heterogametic**. Chances for both types of sperms are equal.

Sex of the baby is determined by the type of sperm. If an X-carrying sperm fertilizes the egg, the zygote will be XX, and a baby girl is born. If a Y-carrying sperm fertilizes the egg, the zygote will be XY: SRY gene expresses itself and a baby boy will be born (Fig 17.31).



P1
♀ X X
X
♂ X Y
Segregation
Gametes
X
X
1/2 X
1/2 Y
100% eggs alike
50% sperms with X
50% sperms with Y
1/2 X
1/2 Y
sperms
1/2 XX ♀
1/2 XY ♂
F1
eggs
X
1 : 1
sex ratio

Fig 17.31: Sex determination in man.

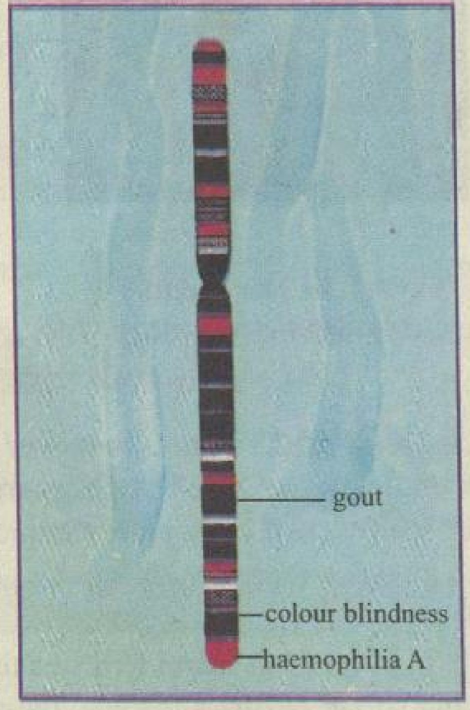
Sex ratio indicates chances of the sex of the baby. Are chances for a son or a daughter not equal?

> A son receives his only X-chromosome from his mother and Y from his father. A daughter receives one X from her father and the other X from mother.

Who is more responsible for determination of sex of a newborn baby, father or mother?

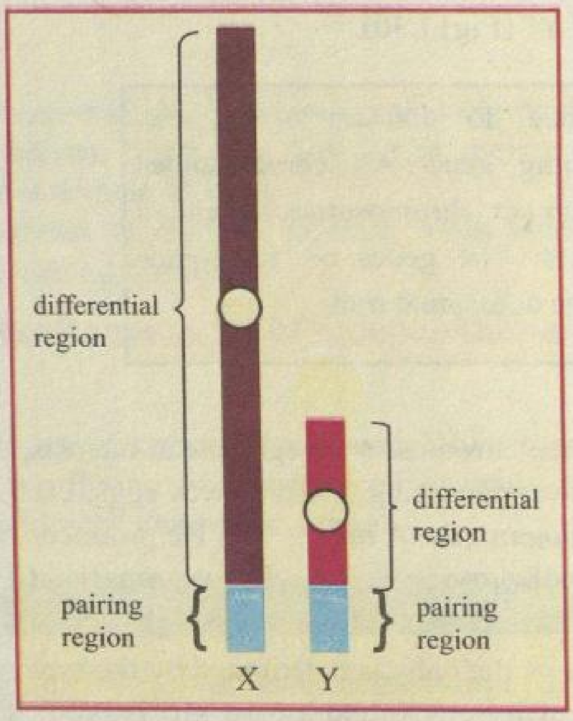
17.9 Sex linkage in man

X and Y chromosomes are different in size. In addition to sex-determining genes they also carry genes for many other traits.



gout
colour blindness
haemophilia A

Fig 17.32: The human X chromosome



differential region
differential region
pairing region
pairing region
X
Y

Fig 17.33: Human X and Y-chromosomes.

Many genes are present only on X-chromosome. These have no corresponding alleles on Y-chromosome. These are **X-linked genes** and their traits are **X-linked traits**; e.g., colour-blindness, and haemophilia. X-linked traits are also commonly called **sex-linked** traits Fig (17.32). A few genes are present only on Y-chromosome, having no counterpart on X-chromosome. These are **Y-linked genes** and their traits are **Y-linked traits**. Y-linked traits are found only in males, e.g., maleness. Some genes are present on both X and Y-chromosomes. These are **X-and-Y linked genes**. As their pattern of inheritance is like autosomal genes, these are also called **Pseudo autosomal** genes.

X being larger has large number of genes, while Y being smaller has small number of genes.

X and Y chromosomes have two distinct regions each due to their linked genes (Fig 17.33).

1. A **pairing region** with common loci of X-and-Y linked genes due to which they synapse during meiosis.
2. A **non-pairing** or **differential** region with different gene loci of either X-linked or Y-linked genes.

17.10 Pattern of sex-linked inheritance:

The pattern of sex-linked inheritance is very specific. It is in a **zigzag** manner. The trait passes from maternal grandfather to daughter and from that daughter to her son. It never comes direct from father to son. As a woman is XX, she carries two alleles for any X-linked trait. She can be homozygous or heterozygous for the trait. But a man being XY can carry only one allele of any X-linked trait on his single X-chromosome. His Y-chromosome does not carry its corresponding allele. He is **hemizygous** for the trait. As Y-chromosome does not carry any counterpart, even a single recessive allele on his X-chromosome can fully express itself. A sex-linked recessive trait can appear in a woman only when she is homozygous for its alleles. That is why chances for a male to be affected by a sex-linked recessive trait are **double** than for a female. This is the reason why **sex-linked recessive traits are more common in males than females**.

X-linked recessive is a trait, which is determined by an X-linked recessive gene. e.g. colour-blindness, Haemophilia.

17.10.1 Red-green colour-blindness:

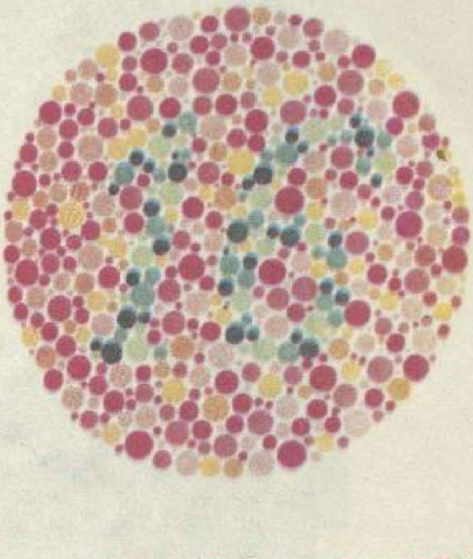


Fig 17.34: A test for red-green colour-blindness

Colour-blindness is a common **hereditary disease**. Colour-blind person cannot distinguish red from green, because red and green sensitive cone cells are absent in the retina of his eyes. Can you see number **16** in Fig 17.34? If yes, you are normal.

It is a recessive X-linked trait. Gene for normal trait is 'C' and gene for colour-blindness is 'c' If a colour-blind man marries a normal woman (Fig.17.35), he will pass gene for this trait to all his daughters through his X-chromosome. He cannot pass this gene to his sons because sons receive only Y-chromosome from him. His every daughter also receives another X but with the normal dominant allele from her mother. She will be phenotypically normal but heterozygous and a **carrier** for this recessive gene. When she marries a normal man (Fig.17.36), she will pass this trait of her father to that half of her sons who inherit grandfather's X from her. The single recessive allele for colour-blindness expresses successfully in a homozygous son because his Y-chromosome does not carry its counter part. Half of her sons will be normal as they inherit grandmother's X with normal gene. Half of her daughters with both normal X will be normal, but half her daughters will be carrier like their mother.

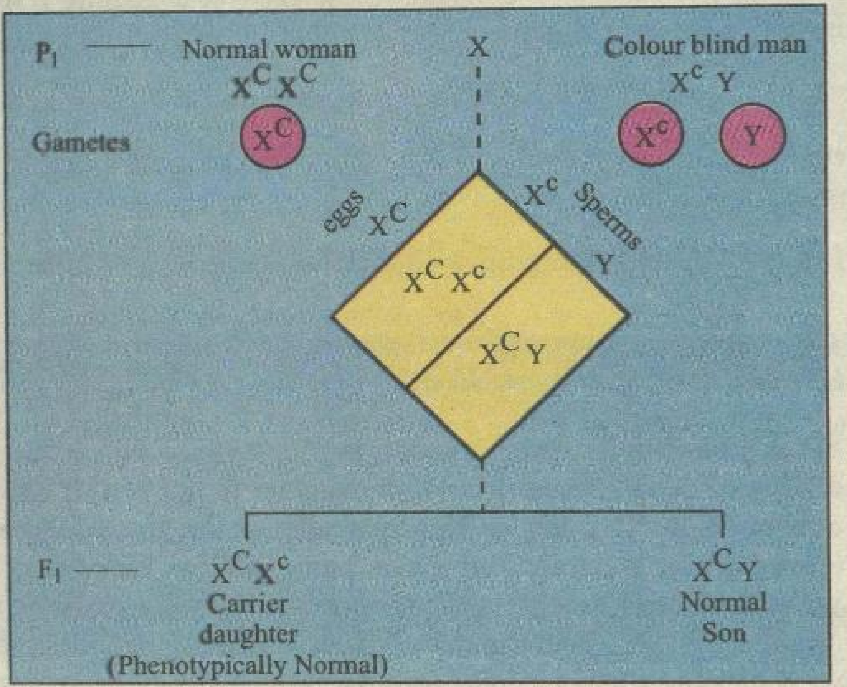

P_1
Normal woman
X^CX^C
Gametes
X^C
X
Colour blind man
X^cY
X^c
Y
eggs
X^C
X^c
Sperms
Y
X^CX^c
X^CY
F_1
X^CX^c
Carrier daughter
(Phenotypically Normal)
X^CY
Normal Son

Fig 17.35

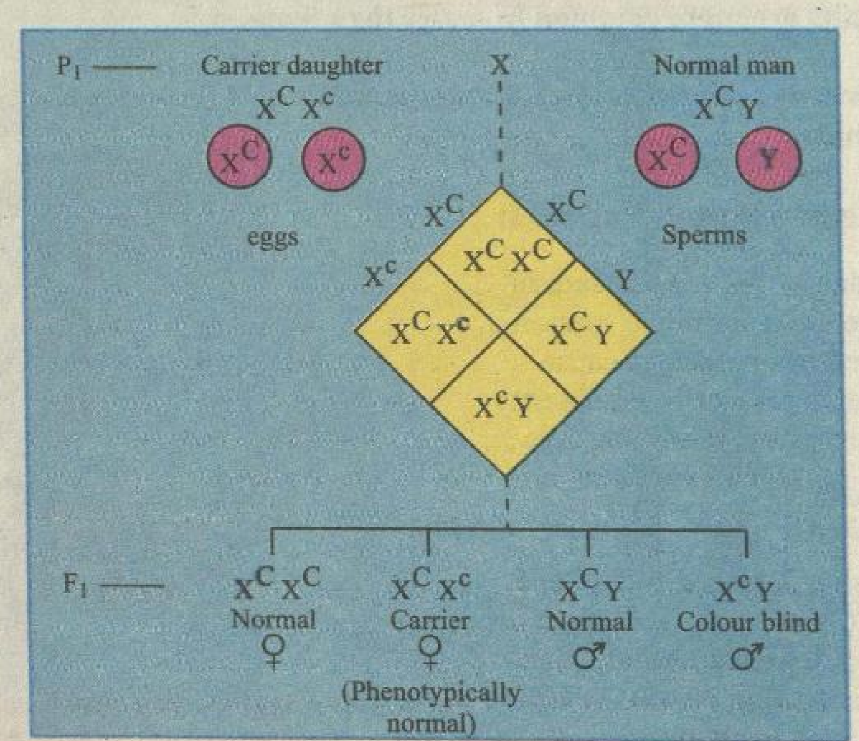

P_1
Carrier daughter
X^CX^c
X
Normal man
X^CY
X^C
X^c
X^C
Y
eggs
X^C
X^c
X^C
Sperms
Y
X^CX^C
X^CX^c
X^CY
X^cY
F_1
X^CX^C
Normal ♀
X^CX^c
Carrier ♀
(Phenotypically normal)
X^CY
Normal ♂
X^cY
Colour blind ♂

Fig. 17.36

Have you noted in both these crosses, that not even a single female is colour-blind?

Have you now understood very well why colour-blindness is more common in men than women?

Activity No. 7: Study of inheritance of colour-blindness in man

Now look at these crosses more carefully again and search for answers to these two simple questions.

Can two normal parents produce a colour-blind son?

Can a normal daughter have a colour-blind father?

Good, you have found your answers from these crosses. Can you answer two more questions by making their crosses yourself?

1. Can two colour-blind parents produce a normal son?
2. Can a colour-blind daughter have a normal father?

17.10. 2 Haemophilia

Haemophilia is a rare but more serious **hereditary disease**. It is an X-linked recessive trait. In this trait the blood fails to clot properly after an injury. It is also called **Bleeders disease**. The affected person may bleed to death even from minor cuts.

In a normal person, many blood-clotting factors interact in sequence to make blood clot. Haemophiliac's blood has either a reduction, or malfunction or complete absence of blood clotting factors.

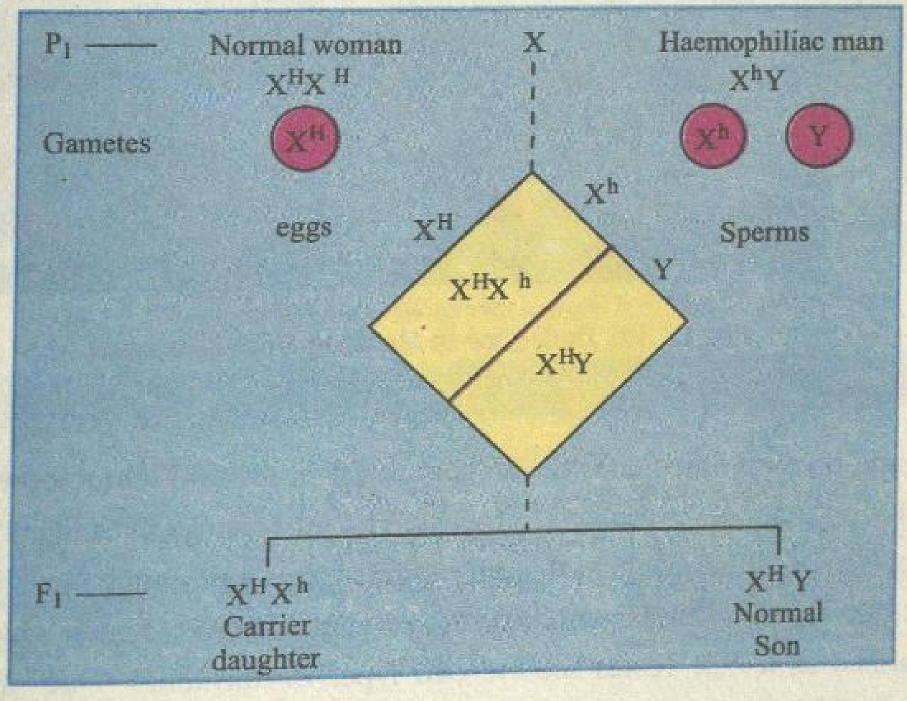


Fig. 17.37: A normal son can have a haemophiliac father

Gene for normal is 'H', and gene for haemophilia is 'h'. Being an X-linked recessive, this trait appears more in men than women. A woman has to be homozygous for its recessive allele to show this phenotype, whereas a man with just one recessive allele will display the trait. Like colour-blindness it also zigzags from maternal grandfather through a carrier daughter to a grandson. It never passes direct from father to son. Do you know why? Can a normal son have a haemophiliac father? Let us get answer by designing a cross (Fig 17.37).

Can a normal son have a haemophiliac mother? No! why not? A normal son needs an X-chromosome with normal gene; while a haemophiliac mother has haemophilia gene on both of her X-chromosomes.

Activity No. 8: Study of inheritance of haemophilia in man

Now please answer by making crosses your self.

1. Can a haemophiliac son have a normal mother?
2. Can a haemophiliac son have a normal father?

17.11 Pattern of Y-linked inheritance

Y-linked traits are passed through Y-chromosome from male to male only. **All sons of an affected father are affected**. Such traits cannot pass to women because they do not inherit a Y-chromosome (Fig. 17.38).

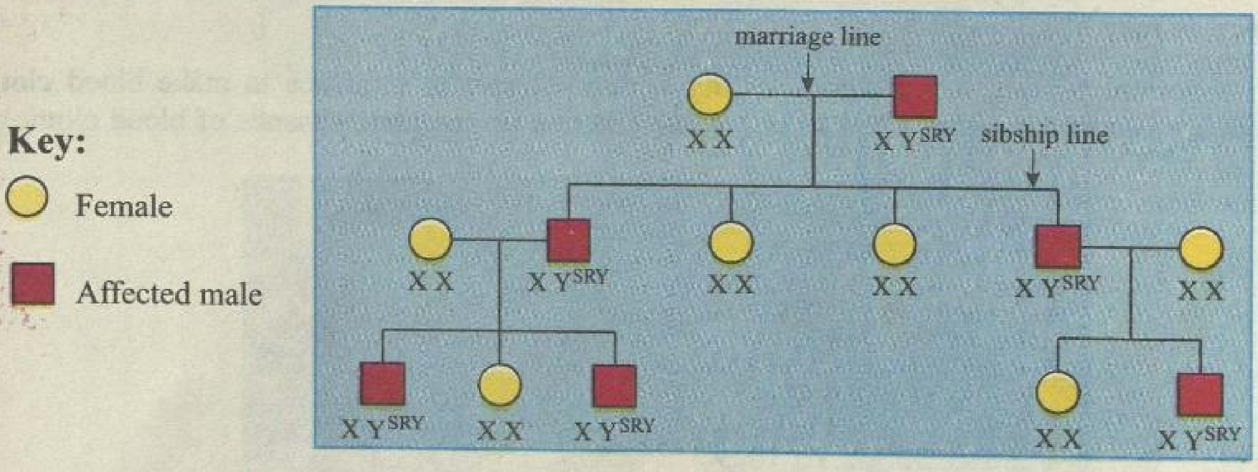


Fig 17.38: Pedigree indicating Y-linked trait.

17.11.1 Maleness:

In 1991 male-determining gene 'SRY' was discovered on Y-chromosome. It is **male sex switch** that switches on male developmental process. The process involves many steps in a sequence controlled by other genes. 'SRY' triggers this process. It forms a protein called "transcription factor" that switches on other genes which complete this process in embryo after week 6. Unspecialized gonads are specialized as testes. Testes secrete two types of hormones. One type stops chances of developing into a female, the other type promotes development of male reproductive structures (Fig 17.39)

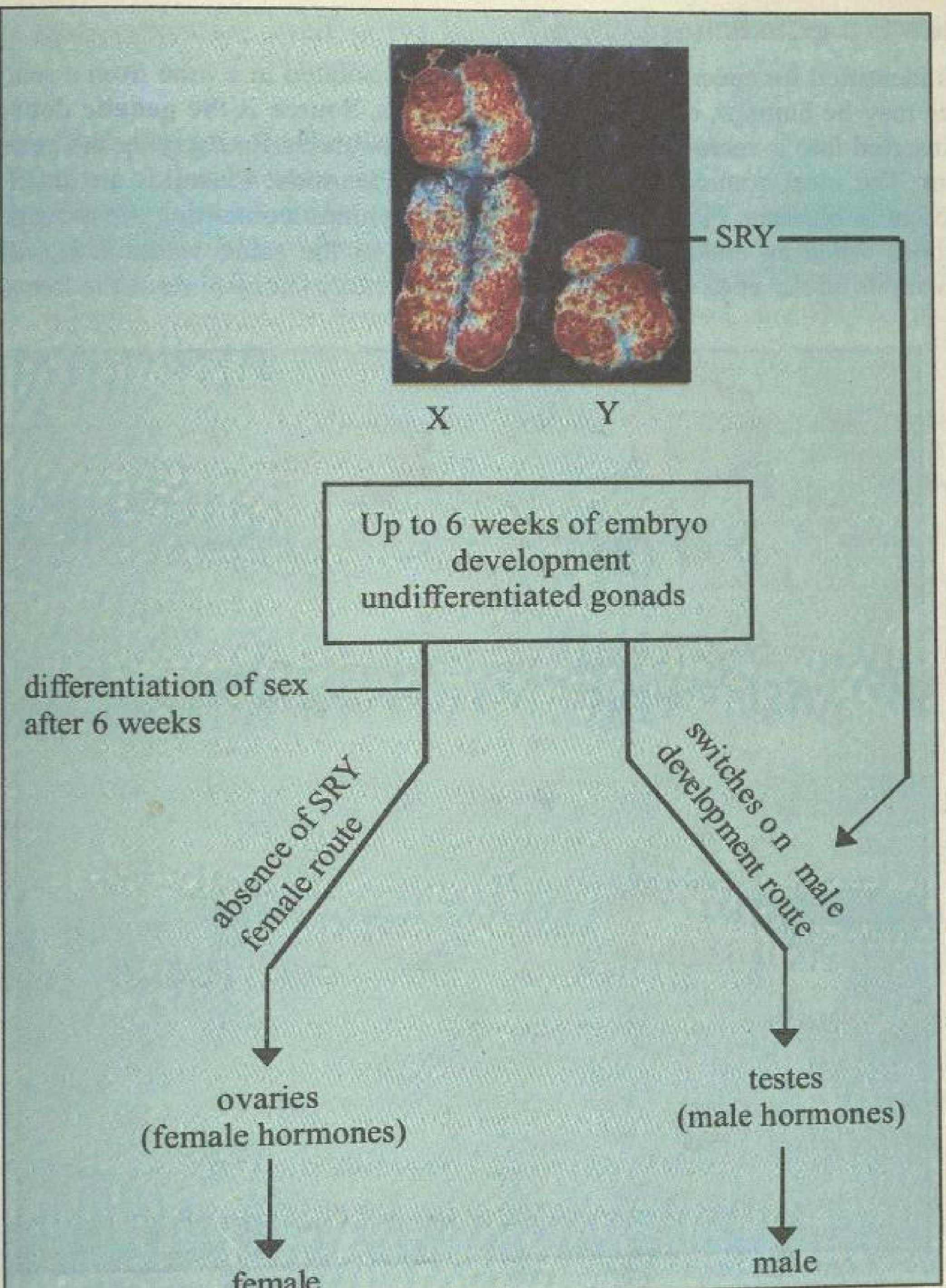

SRY
X
Y
Up to 6 weeks of embryo development undifferentiated gonads
differentiation of sex after 6 weeks
absence of SRY female route
switches on male development route
ovaries (female hormones)
testes (male hormones)
female
male

Fig 17.39: Determination of maleness by 'SRY' gene

17.12 Genetic Engineering

Genetic engineering is a technology of gene/DNA manipulation in lab for human welfare. It has brought revolution in all life sciences. DNA has become a molecular toy in our hand. We can remove or insert any piece of DNA at a specific site in a genome. Malfunctioning genes can be cut and removed; healthy normal genes can be introduced.

Bacteria make restriction enzymes for their own defence. These enzymes cut unwanted DNA into pieces

DNA is cut by molecular scissors called 'restriction enzymes' or **restriction endonucleases,** which cut DNA by making some bases at the ends unpaired, that makes the end sticky. These are obtained from bacteria.

17.12.1 How is a gene transplanted ?

Genes identified for specific proteins are cut and isolated in a tube from a source DNA (Fig. 17.40). Source may be humans, other mammals or plants. Source is the **genetic donor**. The isolated gene is first inserted into a **vector**. Vectors are carrier molecules for carrying the genes to a suitable host bacterium. The most commonly used vectors are **Plasmids**. Plasmids are small circular DNA molecules present in bacteria. Plasmids are placed in a solution containing the desired gene. Imagine what will happen when an endonuclease is introduced in the same solution. It will cut open the plasmid ring with its **sticky ends** exposed. The complementary sticky ends of the free gene will attach with open ends of plasmid by forming hydrogen bonds. Plasmid ring will close again. Another bacterial enzyme **ligase** serves as molecular glue. It will seal the ends. Now the gene has been inserted / spliced in plasmid. Plasmid becomes a **recombinant DNA** after incorporating / splicing another DNA.

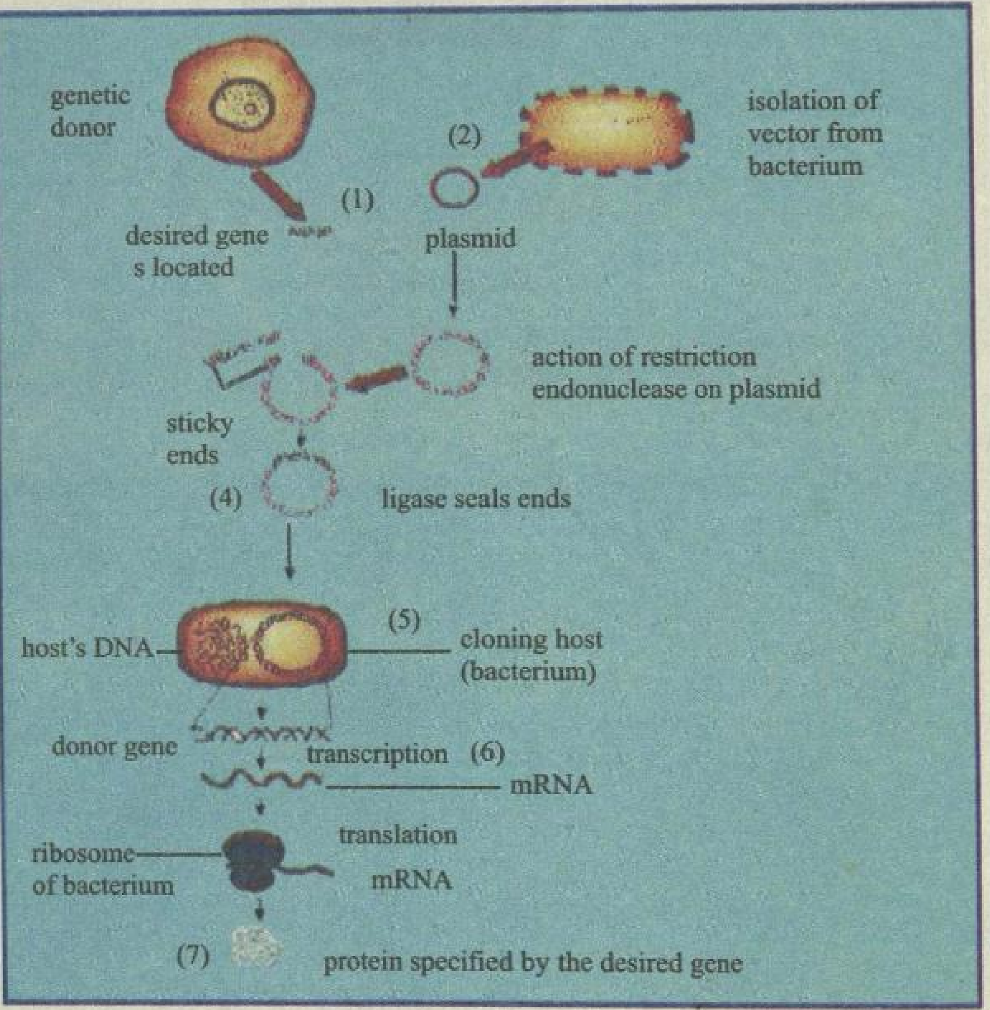

genetic donor
isolation of vector from bacterium
(2)
(1)
desired gene s located
plasmid
action of restriction endonuclease on plasmid
sticky ends
(4)
ligase seals ends
host's DNA
(5)
cloning host (bacterium)
donor gene
transcription (6)
mRNA
translation
ribosome of bacterium
mRNA
(7)
protein specified by the desired gene

Fig 17.40: How is a gene transplanted by genetic engineering.

A DNA molecule formed from DNA's of different organisms is called **Recombinant DNA**.

Now bacteria are chosen as host for cloning this gene. They are exposed to recombinant plasmids. Bacteria take the plasmid in and become recombinant microbes. The bacteria reproduce into a large number of offspring each receiving a copy of the gene. It maintains the foreign gene through multiple generations. In this way multiplication of cloning host amplify the gene. The transplanted gene starts expressing itself in the host. Bacteria make the protein specified by the foreign gene.

17.12.2 Application of Genetic Engineering

Genetic engineering is so useful that several billion dollar industry is based on it. Pharmaceutical companies manufacture hormones, enzymes and vaccines through it. These products cannot be manufactured by any other means. Human insulin for diabetics, Human Growth hormone (HGH) for dwarf children, vaccines for hepatitis B and AIDS patients, and Human interferon for cancer are successfully made from bacteria.

Gene therapy is given to cure patients of hereditary disease like sickle-cell anaemia and haemophilia. HbA gene is placed in bone marrow cells of sickle-cell anaemic by vector. The normal gene HbA starts forming its product and the patient becomes normal. Similarly normal gene for factor VIII is incorporated in bone marrow of a haemophiliac.

Transgenic plants and animals are being made by introducing desired foreign genes into them. Herbicide resistant cotton, and soyabean, pesticide resistant wheat, viral resistant rice and melon, fungus resistant corn, potatoes and tomatoes with built-in-insecticide have been made successfully. Transgenic animals are genetically deigned to improve meat yield. Today transgenic sheep and goats are secreting human drugs in their milk. Have you heard about Nancy and Ethel?

Nancy is a sheep who secretes human ATT in her milk. ATT cures emphysema, a respiratory disease. Ethel is another sheep who secretes human factor VIII in her milk.

17.13 Genetic Engineering Versus Selective Breeding

Selective breeding is another practice to improve domesticated animals and plants. We select for breeding those individuals who have characteristics of our choice. We keep on breeding and selecting individuals generation after generation till either we are satisfied with the product or no further improvement can be done.

Starting from a lean cow with very little milk, selective breeding was done in two directions (i) most milk (ii) most meat; one group of cattle breeders ended with large size modern beef cow with meat enough for lots of kebabs, steaks and roasts, the other group ended with modern dairy cow with lots of milk.

Hybridization and selective breeding have indeed produced a large number of improved varieties of animals and plants like Neeli-Ravi Buffalo, Jersey – Sahiwal cow, Dhani Ox, Kajli sheep, Bital goat, Teddy goat, Rahu –Thaila carp, Broiler and Layer chicken, Maxipak wheat and super kernel Basmati rice but it is a very slow process. It takes months and even years to raise a few generations of animals and plants (Fig 17.41, 17.42).

Genetic engineering has no match. It is a jet – speed process, because it depends on generations of bacteria that take just a few minutes or hours. Moreover the diverse applications of genetic engineering like cloning, gene therapy, finger printing, and gene libraries have absolutely no comparison. Selective breeding is out of fashion, genetic engineering is the most modern.

P₁ ——— Neeli x Ravi

F₁ ——— Neeli– Ravi (fertile)

(The famous Dairy Hybrid Buffalo)

Fig 17.41 Neeli is the famous breed of buffalo selected for centuries in the areas of Punjab where river Sutlej flows. Ravi is the best breed of Ravi areas of Punjab. Their natural hybridization in areas of the common belt of the two rivers like Okara has resulted into famous crossbreed Neeli-Ravi.

Labeo rohita *Catla catla*

P₁ ——— Rahu carp x Thaila carp

F₁ ——— Rahu – Thaila hybrid (sterile)

Fig 17.42:Rahu and Thaila are the two major carps of our rivers famous for their delicious white meat. Rahu – Thaila hybrid combines the superior taste of Rahu with larger size and faster growth rate of Thaila.

KEY POINTS

1. Parents transmit characters to offspring through genes in their gametes. Genes are units of inheritance. These are linearly arranged at specific loci on chromosomes in the form of linkage groups.
2. Mutations produce different alleles of a gene. Crossing over reshuffles the arrangement of alleles in a linkage group. Genetic recombination produces variations that provide raw material for evolution.
3. Genes are short lengths of DNA in chromosomes. DNA is the hereditary material. It stores genetic information in the sequence of its bases in a linear order. It is a unique molecule best suited to store, copy, and transmit biological information from generation to generation.
4. Genotype expresses into phenotype.
5. DNA of every individual is unique.
6. Mendel laid the foundation of genetics by formulating fundamental laws of heredity. He perceived concept of gene at a time when no one knew about chromosomes or DNA.
7. Many autosomal normal human traits and hereditary diseases like Sickle-cell anaemia and Diabetes Mellitus are transmitted in classical mendelian fashion.
8. X and Y chromosomes are sex chromosomes because these have sex determining genes.
9. Pattern of sex-linked inheritance is different from autosomal inheritance. A recessive sex-linked trait like colour blindness or haemophilia zigzags from maternal grandfather through a carrier daughter to a grandson. Y-linked traits like maleness pass directly from father to son only.

10. Genetic engineering is a technology of gene manipulation in lab for human welfare. Its diverse applications have brought a revolution in all life sciences. Though selective breeding has improved varieties of domesticated animals and plants, the transgenic wonders of genetic engineering have no match.

QUESTIONS

1. **Fill in the blanks:**

(i) _______ is the passing on of characteristics from parents to offspring.

(ii) _______ is the basic unit of biological information.

(iii) The chromosomes, which are similar in shape, size and positions of centromere, are called _______ chromosomes.

(iv) The position of a gene on the chromosomes is called its _______.

(v) Partners of a gene pair occupying the same gene locus are called _______.

(vi) _______ is the genetic complement in an individual for a particular trait.

(vii) _______ is the genetic material.

(viii) The four types of nucleotides join to form _______ chain of DNA.

(ix) The two strands of DNA are twisted around each other in the form of a _______.

(x) Adenine pairs with _______.

(xi) During replication each strand of DNA serves as _______.

(xii) RNA is of three types; mRNA, rRNA and _______.

(xii) _______ is an organism that arises from mating between two genetically different parents.

(xiv) Alternative forms of a single gene are called _______.

(xv) In β-chain of sickle-cell haemoglobin at 6th position glutamic acid is replaced by _______.

(xvi) In 23rd pair a man has _______ types of sex chromosomes, but a woman has _______ type.

(xvii) The traits whose genes are present only on X-chromosomes are called _______ traits.

(xviii) The traits whose genes are present on Y-chromosomes are _______ traits

(xix) The most commonly used vectors in genetic engineering are _______.

(xx) A DNA molecule formed from DNAs of different organisms is called _______.

(xxi) Chromosomes other than sex chromosomes are called _______.

2. **Write whether the statement is true or false. Correct the statement if it is false.**

(i) Each daughter DNA double helix contains both new strands.

(ii) During DNA replication guanine pairs with adenine.

(iii) Copying of DNA-coded information into RNA-coded information is Transcription.

(iv) Pea is normally a cross fertilizing plant.

(v) Dihybrids are produced by mating parents differing in one contrasting pair of trait.

(vi) When both the alleles of a gene pair are same, the organism is homozygous for that gene pair.

(vii) Each block of the Punnet square represents phenotype of the offspring.

(viii) A heterozygote forms all gametes of the same type.

(ix) Sickle-cell carriers show no symptoms of disease under normal circumstances

(x) RBC of HbS/HbS person remain normal disc-shaped in normal O_2 concentration.

(xi) Both diabetic parents can produce a normal child.

(xii) In humans, eggs determine sex.

(xiii) Y – linked genes determine traits found only in males.

(xiv) X – linked traits pass direct from father to son.

(xv) X – and – Y linked traits are pseudoautosomal traits.

(xvi) Restriction enzyme is the molecular glue that seals the ends of a recombinant DNA.

(xvii) Selective breeding is a jet-speed process as compared with genetic engineering.

3. Each question is followed by four options. Encircle the correct answer.

(i) Who transmits biological information?
(a) genes **(b)** chromosome
(c) gametes **(d)** nucleus

(ii) What is the diploid (2n) no. of man?
(a) 8 **(b)** 14
(c) 26 **(d)** 46

(iii) Appearance of a trait in an individual is its
(a) genotype **(b)** phenotype
(c) karyotype **(d)** genome

(iv) Crossing over takes place between;
(a) homologous chromosomes
(b) non-homologous chromosomes
(c) sister chromatids
(d) non-sister chromatids

(v) What condenses into a chromosome?
(a) nucleoplasm
(b) nucleolus
(c) chromatin material
(d) cytoplasm

(vi) Chemical analysis of chromatin shows that it is composed of;
(a) protein **(b)** DNA + protein
(c) DNA **(d)** RNA

(vii) What make the backbone of DNA molecule?
(a) phosphate
(b) deoxyribose
(c) nitrogenous bases
(d) phosphate + deoxyribose

(viii) Which is not found in DNA?
(a) thymine **(b)** adenine
(c) uracil **(d)** guanine

(ix) Guanine pairs whom?
(a) adenine **(b)** cytosine
(c) thymine **(d)** uracil

(x) Which triplet in DNA codes for valine
(a) CTT **(b)** AGU
(c) CAT **(d)** AAT

(xi) Only RNA contains
(a) uracil **(b)** ribose
(c) deoxyribose **(d)** ribose and uracil

(xii) Mendel worked on how many contrasting pairs of traits
(a) 5 **(b)** 7
(c) 10 **(d)** 14

(xiii) An individual with heterozygous genotype is a
(a) heterozygote **(b)** hybrid
(c) homozygote **(d)** hemizygous

(xiv) What is the genotypic ratio of offspring of a monohybrid cross?
(a) 1:1:1:1 **(b)** 3:1
(c) **1:2:1** **(d)** 9:3:3:1

(xv) Which gene encodes normal -chain of haemoglobin?
(a) HbA **(b)** HbS
(c) HbB **(d)** SRY

(xvi) Which one is the genotype of a diabetic person
(a) DD **(b)** Dd
(c) dd **(d)** none of three options

(xvii) What is the chance of a diabetic baby born to parents both heterozygous normal
(a) zero **(b)** 1/4
(c) 1/2 **(d)** 3/4

(xviii) What is the Sex-ratio in humans
(a) 1:1 **(b)** 2:1
(c) 3:1 **(d)** 4:1

(xix) Who is responsible for determination of maleness?

(a) x chromosome (b) y chromosome
(c) autosome (d) SRY gene

(xx) Which type of trait colour-blindness is?
(a) atuosomal
(b) X – linked
(c) X – linked recessive
(d) Y – linked

(xxi) Pick out the x – linked recessive trait.
(a) haemophilia
(b) maleness
(c) sickle-cell anaemia
(d) diabetes

(xxii) Which traits are more common in men than women?
(a) x – linked recessive
(b) autosomal
(c) y – linked
(d) x and y linked

(xxiii) What a male can be for an x – linked trait?
(a) hemizygous (b) homozygous
(c) heterozygous (d) heterozygote

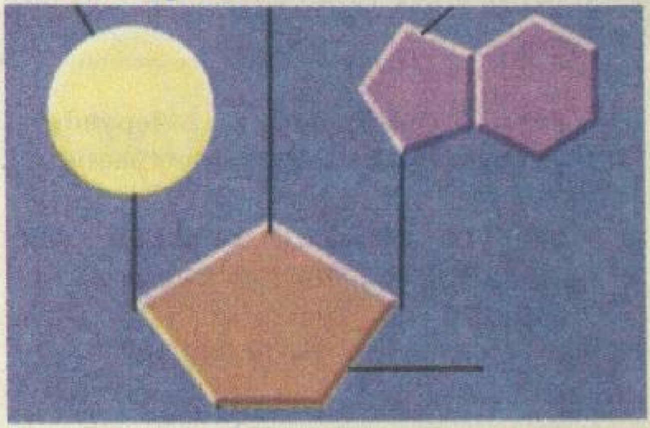
(xxiv) Which traits do not pass to women?
(a) autosomal
(b) sex – linked
(c) y – linked
(d) x – and y – linked

(xxv) Pick out the molecular scissors used in genetic engineering.
(a) plasmid
(b) restriction endonuclease
(c) ligase
(d) genetic donor.

(xxvi) Who secretes human factor VIII in her milk?
(a) Nancy (b) Ethel
(c) Kajli (d) Neeli-Ravi

(xxvii) Who among these was produced by genetic engineering?
(a) Jersey-Sahiwal cow
(b) Dhani ox
(c) Nancy sheep
(d) Rahu-thaila carp

4. Identify the diagram below, label its various parts.



Name: ____________________

5. Differentiate between

Gene and allele

Genome and karyotype

Genotype and phenotype

True breeding and hybrid

Monohybrid and dihybrid

DNA and RNA

Linkage and crossing over

X – linked trait and Y – linked trait

Normal and sickle-cell haemoglobin

6. What is crossing over? Explain it with the help of a diagram. Give its significance

7. What are genes? What is the relationship between genes and chromosomes.

8. Describe Watson and Crick model of DNA.

9. What is the significance of base sequence in DNA? What happens when a point mutation takes place?

10. Describe replication of DNA.

11. How do genes function, to make phenotypes?

12. Explain Mendel's law of segregation.

13. What is a test cross. Explain it with an example.

14. Explain Mendel's law of independent assortment by making a Punnett square.

15. What are necessary conditions for independent assortment of genes?

16. How is sex determined in humans.

17. What is X – linked inheritance? Explain the pattern of inheritance of X – linked recessive trait in man with an example.

18. Explain the inheritance of a Y – linked trait in man.

19. Which gene determines maleness in man? How does it determine maleness.

20. What is genetic engineering? How is a foreign gene transplanted in an organism?

21. What are various applications of genetic engineering for the welfare of mankind?

22. Is the sickle-cell phenotype related to O_2 concentration? Describe the autosomal inheritance of sickle-cell anaemia in man.

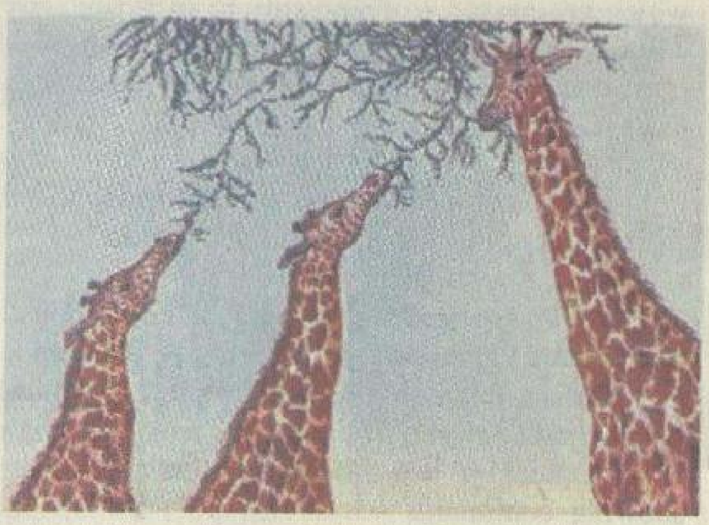
23. Why an X – linked recessive trait is more common in men than women?

18

EVOLUTION

In this chapter you will learn:

- Definition of evolution
- Concept of variation and its causes
- Role of environment in variation
- Important characteristics of Lamarck' s theory of evolution (Lamarckism)
- Salient features of Darwin' s theory of evolution (Darwinism)
- Comparative anatomy and artificial selection as evidences in support of evolution.



Almost two and a half million known kinds of organisms live on the earth today. Each organism lives and functions in its own way. Some organisms resemble closely one another while others do not. A horse and donkey are similar in many ways, but each has some features not found in the other. Many of their features are not found in a dog, and each is very different from a frog or a lizard. The great variety of organisms leads to many questions, such as;

- Why are organisms different? How did organisms obtain different features?
- How can many different plants and animals live in the same environment?
- Was the environment always same as it is now?
- If each organism is suited to its environment; what happens if the environment changes?
- Can organisms change along with their environment to survive?
- Were the organisms existing today present in the same form in the remote past?
- Will today's organisms exist thousands of years after?

Because no one has direct knowledge about these questions, answers to them vary. Biologists attempt to find answers to such questions by using scientific methods that is investigations by means of observations, interpretation, hypothesis formation and experimentation.

As a result of scientific investigations biologists conclude that all the diverse forms of life that are now in existence have come into being through a gradual and continual process of modification of ancestral forms. This "descent with modification" is known as **evolution**. Evolution does not lead to finished final product. The evolution modifies all living things and will continue to produce changes in the future also as it has in the present and past.

18.1 Variation

You might have observed that human beings have many similarities and differences, for example, in height, weight,colour and other body features. One can differentiate between individuals due to these characteristics. The differences shown by the individuals of one kind of organisms are called **variations**. Variations are due to hereditary and non-hereditary characteristics. Characteristics, which are passed from parents to offspring, are called hereditary characters. e.g. eye colour, hair colour, tongue rolling etc. in human beings. Non-hereditary characters are those which are not transferred to offspring, for example, parent's habits and loss of any body part of a person due to disease, accident etc.

In general the term variation means the differences in characteristics of organisms belonging to the same species in a natural population.

Two types of variations, i.e., continuous and discontinuous, occur in any large population. In **continuous variation**, there are small differences among individuals of the same species and many intermediate forms are seen. So there is a complete gradation of many characteristics of organisms from one extreme to the other in a population. e.g., height in human being. Characteristics showing continuous variations are produced due to combined effects of many genes and environmental factors. In **discontinuous variation**, there are sharp differences among the individuals of a species e.g., tongue rolling, blood groups in man etc, which do not show any intermediate forms. Characteristics showing this type of variations are usually controlled by one or two major genes which may have two or more allelic forms and their phenotypic expression is unaffected by environmental conditions.

A person having extra fingers (six fingers instead of normal five fingers) is an example of discontinuous variation.
Intelligence is an example of continuous variation.
Can you name any other discontinuous and continuous variations in human beings?

As a result of these variations, no two organisms are phenotypically identical. In asexually reproducing organisms, there is a little possibility of variation. Any apparent variation between these organisms is certainly the result of environmental influences. Great variety of variations occurs in sexually reproducing organisms. Crossing over and independent assortment during meiosis and random fusion of gametes in fertilization are the important sources of genetic variation in population. The variation in organisms produced by these sources is not under influence of environment. The environment affects at a later stage. In addition, another important primary source of variation among organisms is **mutation**. These variations which occur due to change in the genetic material that have occured gradually and continuously since the life started on earth. These variations are hereditable as these are passed from parents to their offspring in sexual reproduction. These hereditable variations are the raw material for evolution.

18.2 Theories of Evolution

The term 'evolution' has a special place in the study of history of life. In terms of organisms, it may be defined as the development of more advanced and complex organism from preexisting relatively simple (primitive) ancestors over a course of time. Various hypotheses have been developed to account for evolution. The outline of the historical background to the development of history of evolution is given in table 18.1.

Table 18.1. Historical background of development of theory of Evolution.

Scientists	Contribution
Aristotle (384-322 BC)	Proposed theory of continuous and gradual evolution of life from simple to complex and from imperfect to perfect form.
Jean Baptiste de Lamarck (1744-1829)	Concept of use and disuse of organs. Inheritance of acquired characteristics; Environment acts on organisms. Phenotypic changes are passed on.
Thomas Malthus (1766-1834)	Human population increases geometrically and food supply increase arithmatically. This relation results in severe competition.
Charles Lyell (1797-1875)	Evolution is a long time uniform natural process, demonstrated the progressive history of fossil evidence.
Charles Darwin (1809-1882)	Established a theory called "Evolution by means of natural selection".
Alfred Russel Wallace (1832-1913)	Agreed with the theory of Darwin, but excepted humans from the theory.
August Weisemann (1834-1914)	Suggested acquired characters are modifications of soma (body) cells whereas continuity of race is carried out by germ cells (gametes).
Hugo de Vries (1848-1935)	Evolution is due to mutations (sudden change). This sudden change results into new species and not by gradual process of evolution.

From the above table two main theories of evolution have been discussed here to explain the mechanism of organic evolution.

1. Lamarck's Theory of Evolution (Lamarckism). 2. Darwin's Theory of Evolution (Darwinism).

18.2.1 Lamarck's Theory of Evolution (Lamarckism)

In 1809, a French naturalist Jean Baptiste de Lamarck presented the ideas of evolution in his book, *Philosophie Zoologiqe*. These ideas about evolution are called as Lamarckism.

There are two important points of Lamarckism.

(i) Use and disuse of organs. (ii) Inheritance of acquired characters.

(i) Use and Disuse of Organs

Fig. 18.1 Jean Baptiste de Lamarck

According to Lamarck, in organisms certain changes in the body features are developed by use and disuse of body parts due to biological needs arising out of environmental changes. The organ greatly used develops in its size and organ disused tends to become weaker and can eventually disappear. This statement of Lamarck that use or disuse can produce changes in organs seems correct e.g., the development of muscles in athletes and the development of calf muscles in ladies who wear high heels are common observations.

(ii) Inheritance of Acquired Characters

Variations in phenotype due to use or disuse of body are called acquired characters as these characters are developed during the life time of an individual. Lamarck believed that these acquired characters are inheritable and are passed on to the offspring from their parents during reproduction.

Lamarckism is illustrated by an example of giraffe's long neck. Lamarck assumed that long necked giraffes evolved from short-necked ancestors. The short-necked ancestors could graze on grasses. When the grasses became scanty the giraffes tried to stretch their necks to reach the top of trees to feed on leaves. As a result of these efforts the giraffes' necks became longer. The same trend continued and the neck went on becoming longer and longer. The giraffes with long necks were able to survive in such an environment. Lamarck believed that acquired characters of long neck in giraffes was heritable and was passed on to the next generation. He believed that gradual accumulation of such changes lead to the evolution of individual which are better suited to their environment.

Regarding disuse of organs, Lamarckism can be described with the help of an example of snakes. Ancestors of modern snakes had four legs with which they used to move on land. In order to escape from enemies the snakes started hiding in holes and creeping in narrow cracks in rocks. In this new mode of life the legs were not used, but muscles of their bodies were used more for creeping. As a result of disuse, the legs were completely lost and body of snakes become elongated and cylindrical. This is how present day snakes have evolved.

Webbed feet of aquatic birds is another example of use of organs, and non-functional wings of Kiwi and Ostrich are the examples of disuse of organs. In human beings appendix (small sac of unknown functions connected to large intestine) and coccyx (fused tail bones) are the result of disuse of organs, as per Lamarck's theory of evolution.

Lamarck's theory of evolution lays emphasis on biological needs, which arise as a result of change in environment. This need produces an urge in the organism to use or disuse certain organs which then develop or degenerate as a consequence there of. As already discussed Lamarck believed that these variations were inheritable. That these changes were inheritable could not be established. To demonstrate this, **August Weisemann** in 1870 cut off the tails of mice over many successive generations. In each generation the mice were born with normal tails. According to Lamarckism, the acquired character (mice without tail) would be inherited. But this was not the case. Weisemann postulated that somatic (body) acquired characteristics resulting in phenotypic changes did not directly affect the germ cells (gametes) which are the means by which characteristics are passed on to the next generation.

18.2.2 Darwin's Theory of Evolution (Darwinism)

Charles Darwin (1809-1882) while on voyage aboard on a ship (HMS Beagle) made observation about the great variety of birds and reptiles on the Galapagos Islands and their relationship to similar groups on the Ecuadorian mainland.

Charles Darwin was also inspired by the work of his geologist friend Charles Lyell whose major thesis was that geological forces produce a constant changing environment. He also came across an essay on population written by a clergyman and economist Thomas Malthus, who maintained that the human population tend to increase at a much greater rate than does the food supply necessary to sustain the population.

Darwin studied essay outlining a similar theory of evolution by another naturalist Alfred Russel Wallace who observed diversity in plants and animals and their peculiar distribution in South America, Malaya and Indian Archip elago. He was also aware of the practices of plant and animal breeders in producing, in a few generation, the desired traits in domestic animals and plants by artificial selection.

All this knowledge helped Charles Darwin to propose the theory of evolution by natural selection. He presented his theory at a scientific meeting of Linnean Society in London (1858) and published his famous book named "*The Origin of Species by Means of Natural Selection*" in 1859. It created a storm of controversy but generated a favorable band of supporters.

Fig. 18.2. Charles Darwin.

The salient features of Darwin's theory of evolution are:

(i)	Overproduction	**(ii)**	Heritable Variations
(iii)	Competition for Survival	**(iv)**	Natural Selection

(i) Overproduction

All organisms tend to reproduce in geometrical progression (1, 2, 4, 8, 16, 32, …, 2^n). If all the organisms produced remain alive it would result in millions of organisms of a single species on this earth in a matter of a century even in the case of slow breeders such as elephants.

(ii) Heritable Variations

Darwin noticed that not all individuals of a species when born are alike. He realized that some of the variations were useful to individuals carrying them as these variations helped them to live comfortably in that environment. These individuals could adapt to their environment more than the individuals which did not possess these useful variations.

(iii) Competition for Survival

The available resources of the environment for example, food, water, shelter, etc, are limited. Food can increase in arithmetic fashion (1, 2, 4, 6, 8, 10, …). We have seen that organisms population increase in geometric progression (2^n). Therefore ratio of organisms to food etc; reach unmanageable proportion and leads to a secure struggle for survival. The individuals of a species compete with each other and with individuals of other species to get their food etc.

(iv) Natural Selection

In this competition for survival or struggle for existence, the variants that are better adapted to a particular environment are successful and continue to produce offspring with their adaptive characteristics. Over time the characteristics, which provide adaptiveness or fitness come to accumulate in the population than those characteristics, which decrease fitness. The greater reproductive success of the better adapted form constitute the natural selection. This means to say that better adapted individuals (with useful variations) are favoured by nature to survive and reproduce, as compared to individuals which are not fit for that environment.

Now question is "How would Darwin have explained the giraffe's long neck?"

According to Darwin the original giraffe population had variations in the length of their necks, some individuals were with short necks and some with long necks. The long necked giraffe would eat leaves of the trees as well as grass on the ground. When the grass became scarce, the long necked giraffe could obtain more food from the top of trees than short-necked giraffe and were more likely to survive and reproduce. This favourable variation of long neck was inherited by the offspring generation after generation. The present long necked giraffe is the result of process of evolution.

Darwin's theory of natural selection was reasonable and supported by arguments that is why it was accepted by many scientists.

A comparison of Lamarckism and Darwinism with example of giraffe's neck is given in table 18.2.

18.3 Evidence of Evolution

There are number of evidences which support the theory of evolution. These evidences are based on data obtained from many sources and in all cases the interpretation shows that evolution does occur.

Evidence for evolution comes from many fields as for example geology, biogeography, comparative anatomy, embryology, artificial selection and molecular biology. However we shall discuss only the evidences from comparative anatomy and artificial selection in this book.

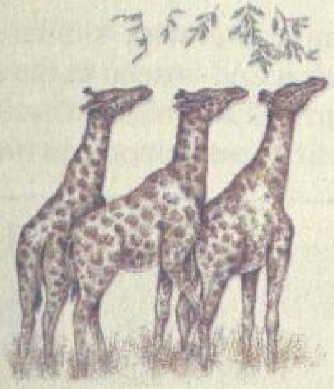
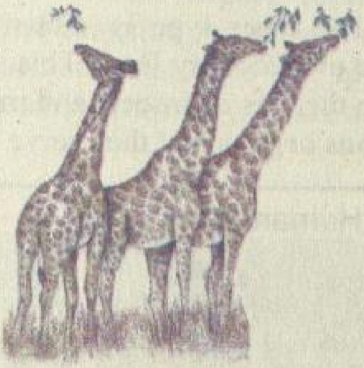
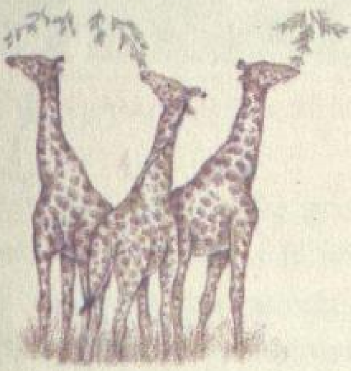
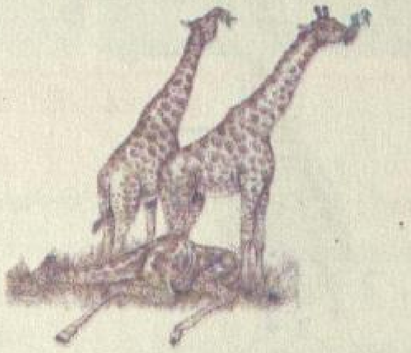
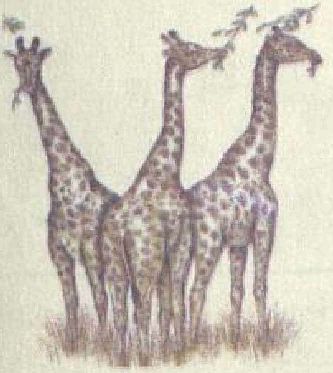
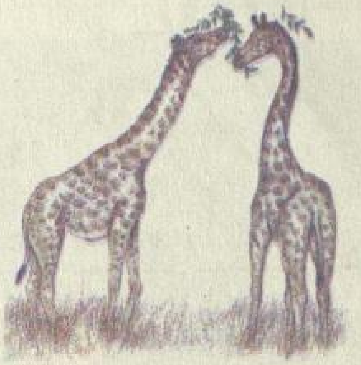
The theory of evolution as proposed by Darwin has been modified in the light of modern evidence from genetics, molecular biology, palaeontology, ecology and ethology (the study of behaviour) and is known as **neo-Darwinism** or **synthetic theory of evolution**. This may be defined as the theory of organic evolution by the natural selection of inherited characteristics

18.3.1 Comparative Anatomy

Evidence from comparative anatomy consists of two major types. One is the underlying similarity of comparable structure of pentadactyl limbs (penta:five and dactyl:digits) in different species (fig 18.3). The arm of a man, the forelimb of horse, the flipper of a whale, the wings of bird and the

In human body, certain structures are considered vestigial e.g., human appendix, although not concerned with digestion is homologous with functional appendix of herbivorous mammals. The vertebrae of human coccyx are thought to represent vestigial structure of the tail possessed by our ancestors and embryos. Likewise non-functional bones in snakes and whales are thought to be homologous with hipbones and hindlimbs of vertebrates

Table. 18.2 Comparison of Lamackism and Darwinism.

Lamarckism	Darwinism
 (a) Ancestral giraffes probably had short necks and by continuous stretching enabled the giraffes to reach the leaves of trees.	 (a) Ancestral giraffes probably had necks of various lengths. The variations were hereditary.
 (b) The offsprings had longer necks that were also stretched frequently in search of food.	 (b) Competition and selection led to survival of longer necked offsprings at the expense of shorter necked giraffes.
 (c) Eventually the continued stretching of the neck gave rise to modern giraffes.	 (c) Eventually only long necked giraffes survived the competition.

forelimb of a bat, all contain similar bones and muscles. Since these structures have different functions but their structural resemblance indicates that they were modifications over a time of some common ancestral structure. The term **homology** is applied to this phenomenon and such organs which are structurally alike but functionally different are known as **homologous organs**. The evolutionary process producing these organs is called **divergent evolution.**

The other type is shown by the development of structure with similar function in very different evolutionary lines. This is called **convergent evolution** and is seen in the close resemblance between the legs of insects and mammals and wings of butterflies and birds. These organs are called **analogous organs** and they serve similar functions but have different anatomical origin.

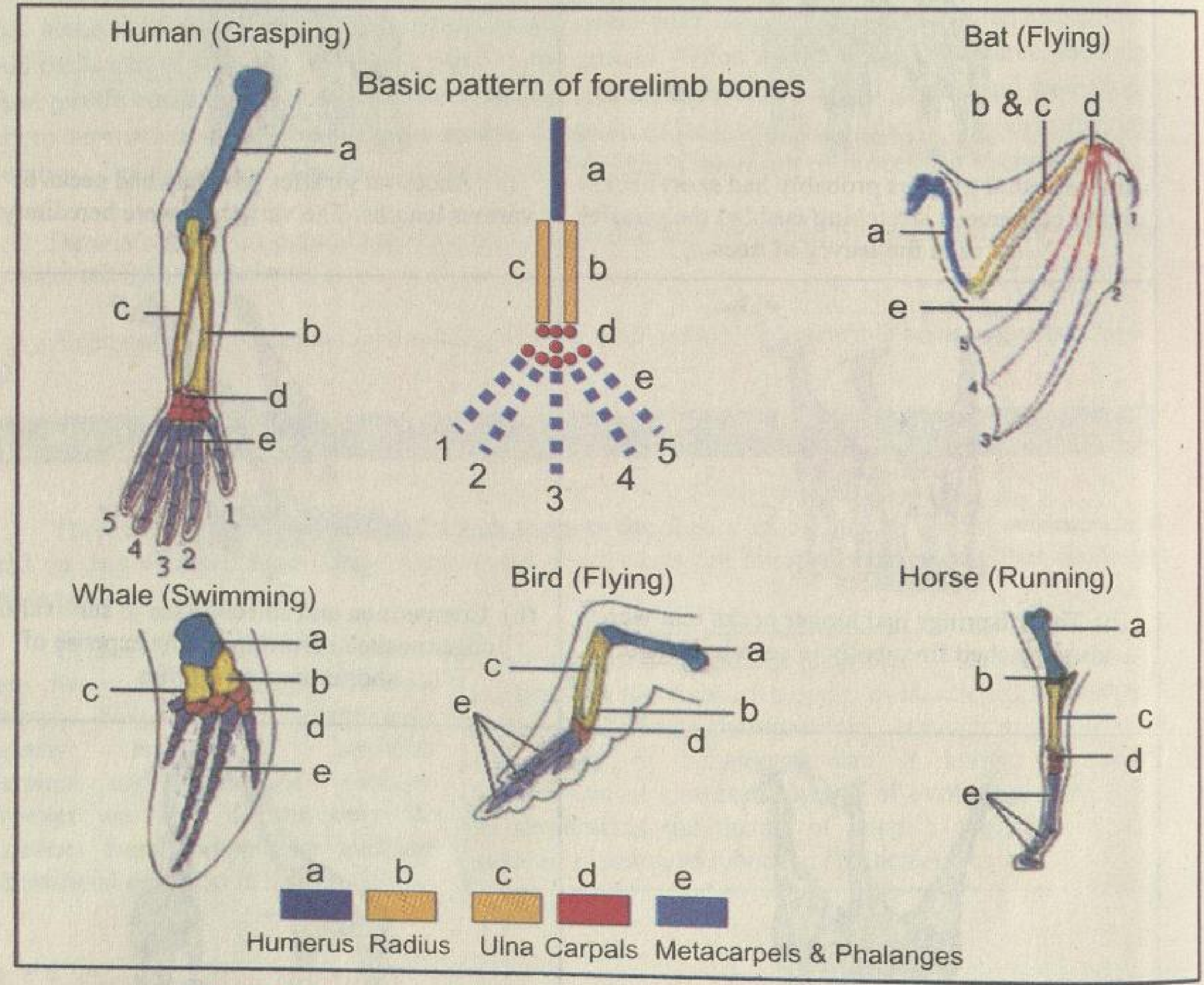

Human (Grasping)
a
c
b
d
e
5
4
3
2
1
Basic pattern of forelimb bones
a
c
b
d
e
1
2
3
4
5
Bat (Flying)
b & c
d
a
e
Whale (Swimming)
a
c
b
d
e
Bird (Flying)
c
a
e
b
d
Horse (Running)
a
b
c
d
e
a Humerus
b Radius
c Ulna
d Carpals
e Metacarpels & Phalanges

Fig. 18.3 Pentadactyl limb (center) and its modifications depending on life style of various animals.

Another source of evidence for evolution in comparative anatomy is the existence of **vestigial organs**. These are the body parts that were presumably functional at an early time in the ancestral form but have since become remnants. The presence of vestigial organs is an evidence in favour of evolution because it would be much harder to account for non-functional vestiges without having been inherited from some ancestor where these were functional.

18.3.2 Artificial Selection

One of Darwin's most difficult tasks was to convince biologists that selection can produce change within a species. He supported his argument by pointing out that farmers and breeders have developed many varieties of animals and plants through artifical selection. In addition Darwin himself bred pigeons and got variety in colour, size, form and behaviour (figure 18.4) through artificial selection which gave him a clue to the concept of artificial selection but he was unable to appreciate how this could operate in nature. Darwin used this observation to argue that species can change and that its characters are not fixed. He said if change is possible artificially, a similar process of change of selection can also occur in nature.

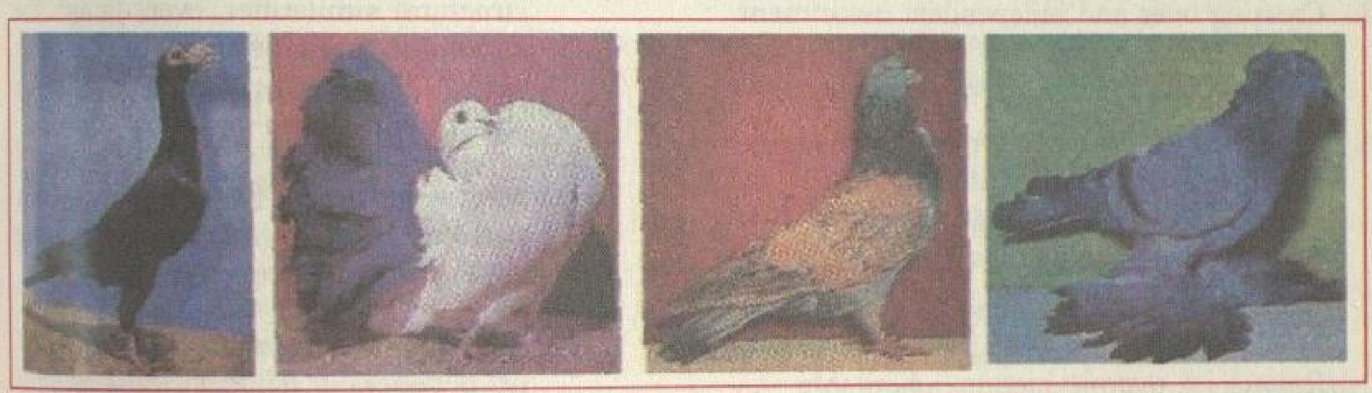
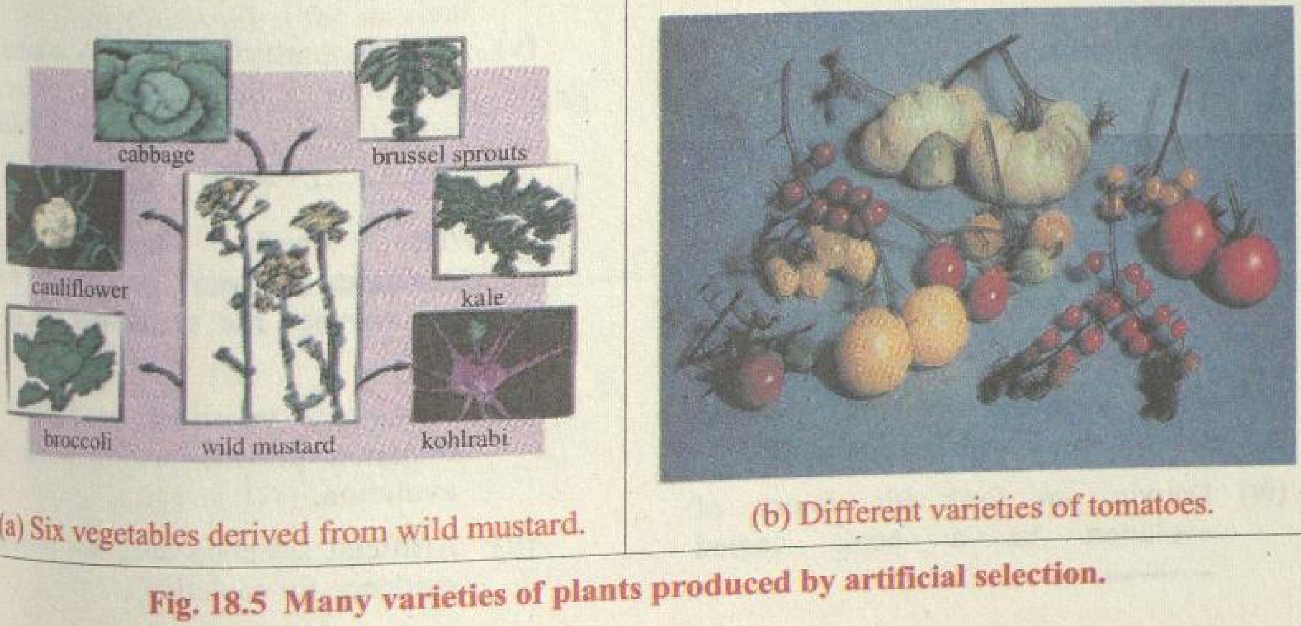


Fig. 18.4 Many types of pigeons produced by artificial selection.

Now a days biologists have produced completely new varieties of animals and plants by artificial selection. It is the process in which organisms with the 'best' or 'desired' traits/ characters are selected and bred with one another so that the traits/characters would be passed on to the offspring. Numerous varieties of animals (e.g., sheep, goats, cows, hens) have been produced by artificial selection to increase production of meat, milk, wool etc. Similarly many plant varieties (fig. 18.5) for example cereals, fruits, vegetables etc. are produced for better quality in production and taste by artificial selection.



(a) Six vegetables derived from wild mustard.

(b) Different varieties of tomatoes.

Fig. 18.5 Many varieties of plants produced by artificial selection.

KEY POINTS

1. Evolution is the process of gradual change in living things with the passage of time.
2. Individuals vary from one another and these differences among individuals are called variations. There are hereditary, non-hereditary, continuous and discontinuous variations in organisms.
3. Crossing over and independent assortment during meiosis and mutation (gene and chromosome) are the causes of variations.
4. According to Lamarck organisms acquire new characteristics by use and disuse of organs. These acquired characteristics were thought to be inherited by offsprings.
5. Darwin proposed the theory of evolution by natural selection, which has four salient features i.e. overproduction, inheritable variations, competition for survival and natural selection.
6. Lamarckism and Darwinism are based on different principles. Lamarck's theory says that ancestral giraffes had short necks and by continuous use to reach the leaves of trees, has elongated and adapted whereas Darwin's theory says that ancestral giraffes had necks of various lengths. With continuous selection, a race of long necked individual was established.
7. The concept that evolution has occurred is supported by comparative anatomy and artificial selection:-

   (a) Homologous Structures have basic structural similarities, even though the structures may be used in different ways. They derive from the same structure in a common ancestor.

   (b) Analogous organs are the organs which perform similar functions but have different anatomical origin.

   (c) Vestigial Structures are non-functional or degenerate remnants of structures that were present and functional in ancestral organisms.

   (d) Artificial selection is the process in which organisms are selected for production of new organisms with desired characteristics.

QUESTIONS

1. **Fill in the blanks.**

   (i) The process of gradual change in living things with the passage of time is known as ________.

   (ii) The variations that are passed on from generation after generation are called ________ variations.

   (iii) In 1809 ________ presented the idea that organism evolved through inheritance of acquired characters.

   (iv) Darwin put forth his theory of evolution in a book named ________.

   (v) Organs which perform similar functions but have different anatomical origin are called ________ organs.

2. **Write whether the following statements is "true" or "false" and then correct the statement if it is false.**

   (i) Hereditary variations produced by mutation provide raw material for evolution.

   (ii) Artificial selection does not provide evidence for evolution.

(iii) According to Darwin changes in the environment are responsible for bringing changes in characters of organisms.

(iv) The wings of Kiwi and Ostrich are examples of vestigial organs having no useful function.

(v) Lamarck proposed the theory of natural selection.

3. **Each question is followed by four options. Encircle the correct answer.**

(i) Which of the following is not a part of Darwinism?
(a) Overproduction
(b) Natural Selection
(c) Inheritance of acquired characters
(d) Competition for survival.

(ii) According to Lamarck the organs which are used more are:
(a) Better developed
(b) Less developed
(c) Completely lost
(d) Remained same.

(iii) Which one of the following is a part of Lamarckism?
(a) Overproduction
(b) Inheritance of acquired character
(c) Competition for survival
(d) Natural Selection.

(iv) The favourable variation tends to be:
(a) Passed on to next generation
(b) Eliminated
(c) Remain unnoticed
(d) None from a, b & c.

4. **Give short answers to the following questions.**

(i) Define evolution.

(ii) What do you mean by variation?

(iii) Distinguish by giving examples:-

(a) Hereditary variation and non-hereditary variation

(b) Continuous variation and discontinuous variation

(c) Homologous organ and analogous organ.

(d) Convergent evolution and divergent evolution

(iv) Name two major sources of variation.

(v) Give two examples of vestigial organs of human beings.

(vi) What is artificial selection?

5. **Describe Lamarck's theory of evolution.**

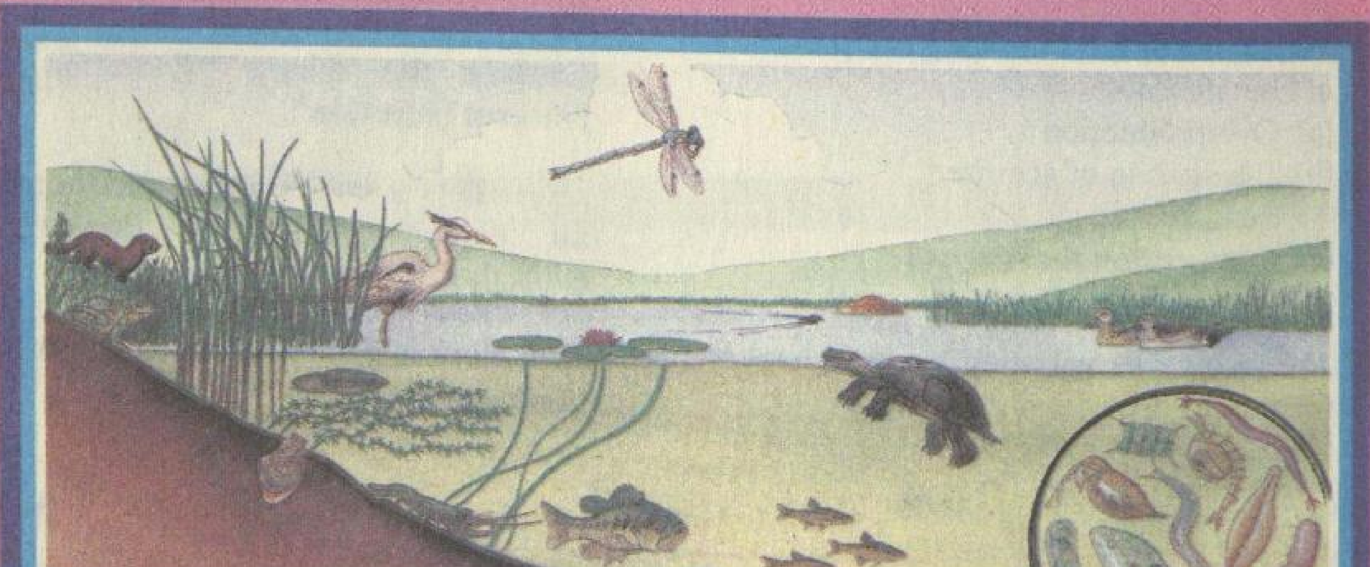
6. **Explain the theory "Evolution by Natural Selection".**

7. **Describe comparative anatomy as an evidence for the theory of evolution.**

8. **How does artificial selection support the theory of evolution? Explain.**

Section 7

Interrelationship of Organisms with their Environment



19

ENVIRONMENTAL BIOLOGY

In this chapter you will learn:

- Factors that affect an area's ability to support life.
- How changes in the environment might affect organisms.
- The structure of an ecosystem.
- How habitat destruction leads to loss of biodiversity.
- Roles of producers, consumers and decomposer in the ecosystem.
- The concept of trophic levels.
- Food chains and food webs.
- The movement of energy through an ecosystem.
- Ecological pyramids and their relationship to energy flow in an ecosystem.
- The water cycle, the nitrogen cycle and the carbon cycle.
- Predator-prey, host-parasite and symbiotic relationship and their effects on populations.
- The concept of ecosystem balance, and how humans are affecting this balance.

Every thing that surrounds an organism is its environment. An organism's environment, which is a complex of many physical and biological factors, provides every thing the organism needs in order to live. The environment provides food, water, shelter, air, and other resources. If conditions in the environment change, the organism may not be able to survive.

In any environment living organisms show complex relationships among themselves and with their non-living or physical environment. **Ecology** is the study of the relationships of living organisms with each other and their non-living or physical surroundings. Ecology deals with distribution and abundance of life on earth, ecological roles of specific species, interaction among species in communities, maintenance of ecosystems and environmental degradation.

19.1 Parts of the Environment

All factors that make up the environment can be divided into two categories: living and non-living. All living parts of the environment are called **biotic factors**. Biotic factors in the classroom may include only humans and microbes too small to see. If you were passing through a forest, the list of biotic factors in that environment would be larger. The list might include plants, birds, mushrooms, insects and so on (Fig 19.1 & 19.2).

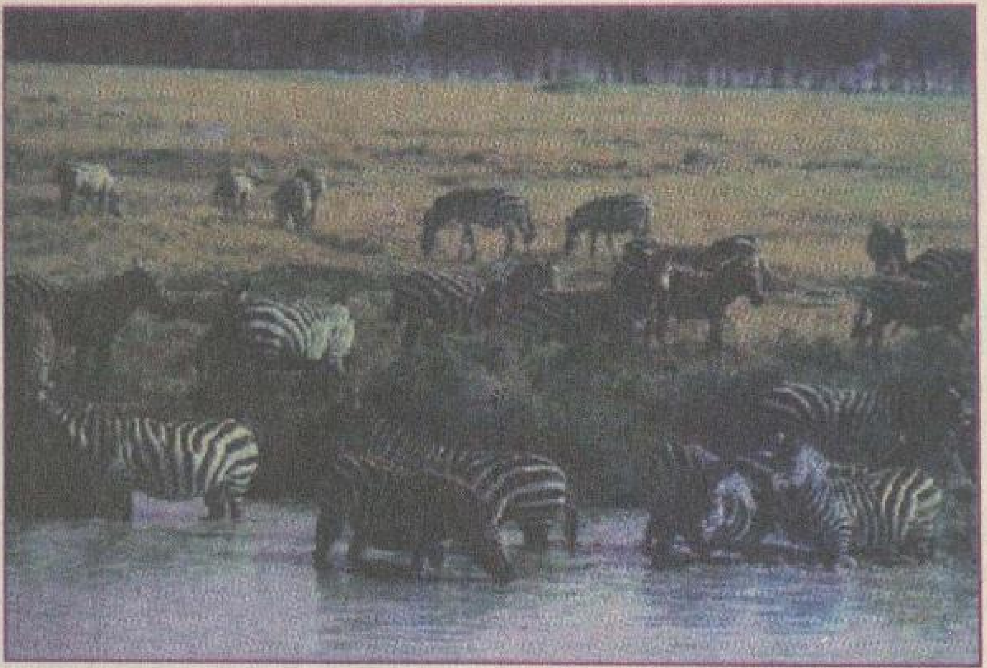
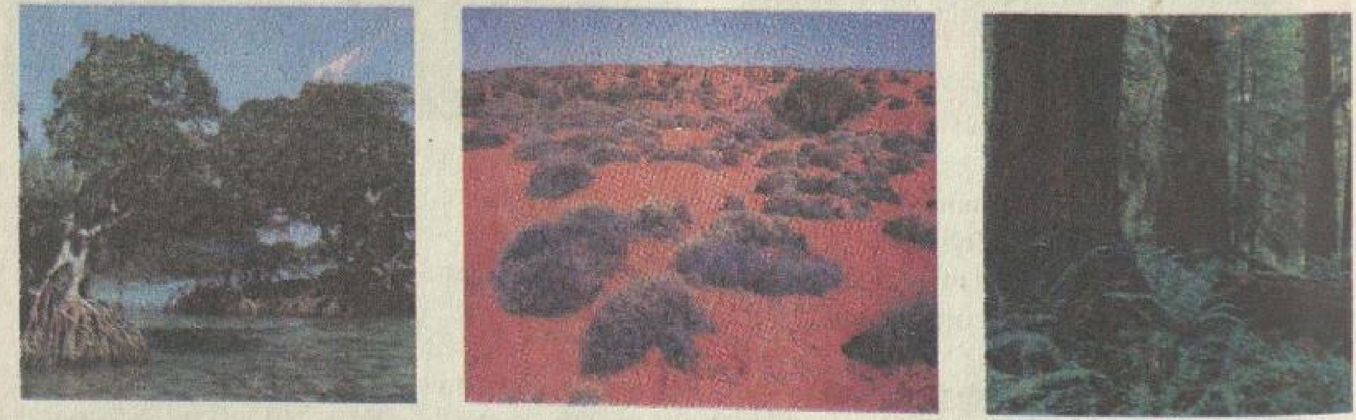


Fig 19.1. Environment provides every thing the organisms need

All the non-living parts of the environment are called **abiotic factors**. Abiotic factors include water, soil, and air, as well as temperature, wind, and sunlight. Some of the abiotic factors in an environment may once have been alive, such as your class room's wooden chairs, which came from trees. Because the wood is no longer alive, it is therefore not a biotic factor.



(a) Aquatic environment. **(b) Desert environment.** **(c) Forest environment.**

Fig 19.2. Every environment has its own set of characteristics

19.2 Environmental Interactions

Organisms interact with the biotic and abiotic factors in the environment. An organism may be affected by the changes in the environment, and the environment may be affected by the organism. The change in the environment may, in turn, have an effect on other organisms.

19.2.1 The Ecosystem

Interactions in the environment result in the establishment of an organized ecological system or ecosystem. An ecosystem is not simply a random collection of organisms and environmental factors. An ecosystem is a highly organized, structured environment in which all parts exist in a delicate balance. Ecosystem can be studied at a variety of levels from individual species to the entire ecosystem.

Species

A species is a group of organisms so similar to one an other that they can breed in nature and produce fertile off-springs. All the members of a species have similar needs, such as types of food and place of living. Because they have the same needs, members of a species often compete with one another for the resources.

Habitat

The type of environment in which a particular species lives is its habitat. For example, the tops of the trees in a pine forest may be the habitat of a species of birds. A shallow, fast moving, cold water stream may be the habitat of a species of trout. A rotting log is an ideal habitat for various species of insects, fungi, and micro-organisms. The habitat provides the appropriate type of food, shelter, temperature, and so on that members of the species need to live (Fig 19.3).

Disturbing the part of an ecosystem that an organism needs to survive is called habitat destruction. Cutting down the trees in a forest is one form of habitat destruction. The destruction of habitats is a serious threat to the survival of many species.

Fig. 19.3 An organism can live in a particular type of environment

Populations

Population is a group consisting of members of the same species that live together in the same area at the same time (Fig 19.4a). For example, in 1998, 0.56 million people were living in Quetta. We can say that human population of Quetta in 1998 was 0.56 million.

Similarly, all the mango trees in a fruit garden in a particular year constitute population of mango in that fruit garden.

Communities

Populations do not live alone in their environments. In any region, many different populations share the same space. These population interact with one another in a variety of ways. All populations that live and interact in the same environment make up a **community** (Fig 19.4b).

Ecosystems

An ecosystem includes all the communities that live in an area, as well as the abiotic factors in the environment (Fig 19.4c). Ecosystems therefore include the water, soil, and climate in the area. A healthy ecosystem includes a wide variety of species in its community. The variety of species in an ecosystem is known as **biodiversity**.

If enough of a particular type of habitat is destroyed, the species that live in the habitat can die out completely, or become extinct. When species become extinct, biodiversity in the ecosystem is reduced.

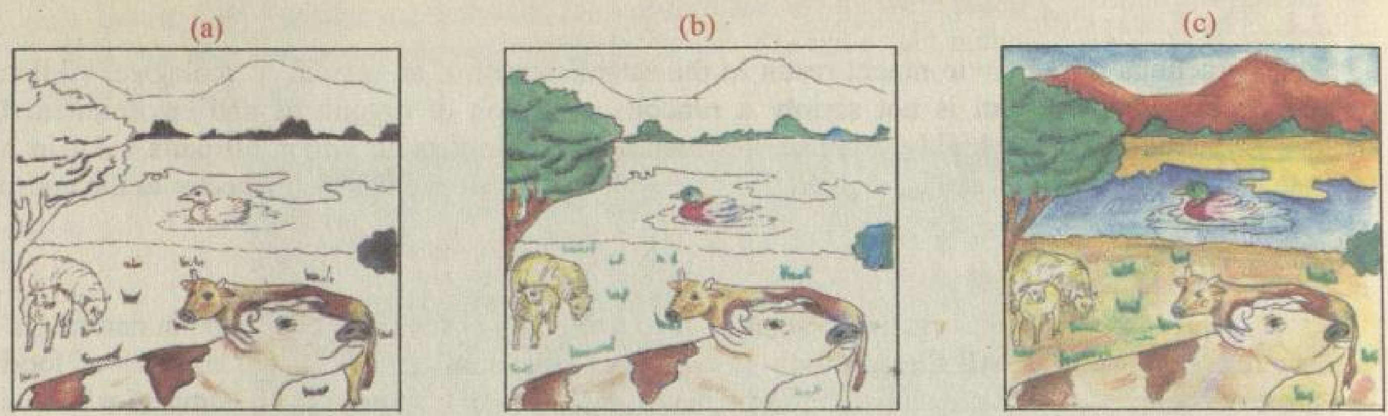


Fig. 19.4 All the members of a species that live in an area are a population (a). All the populations in the area make up a community (b). Communities together with the abiotic factors form an ecosystem (c).

Where Have They Gone!

Natural tropical thorn forests once formed one of the most remarkable landscapes of the Indus basin plains in Pakistan. These forests extended from the foothills of the Himalayas (Jhelum) to the Arabian sea (Karachi). These forests (also called Rakhs in the Punjab) were a source of forage, firewood, medicine and fruit. They also supported a thriving wildlife.

As a consequence of habitat destruction due to land reclamation and extensive canal irrigation system, overgrazing, and large scale falling for firewood, these forests have almost disappeared in the Punjab. Some dominant species of this forest system, such as *Salvadora oleoides* (Wan, Peelu) can only be found in scattered remnant patches in the Southern Punjab districts of Bahawalpur, Mazaffargargh etc, or in old graveyards.

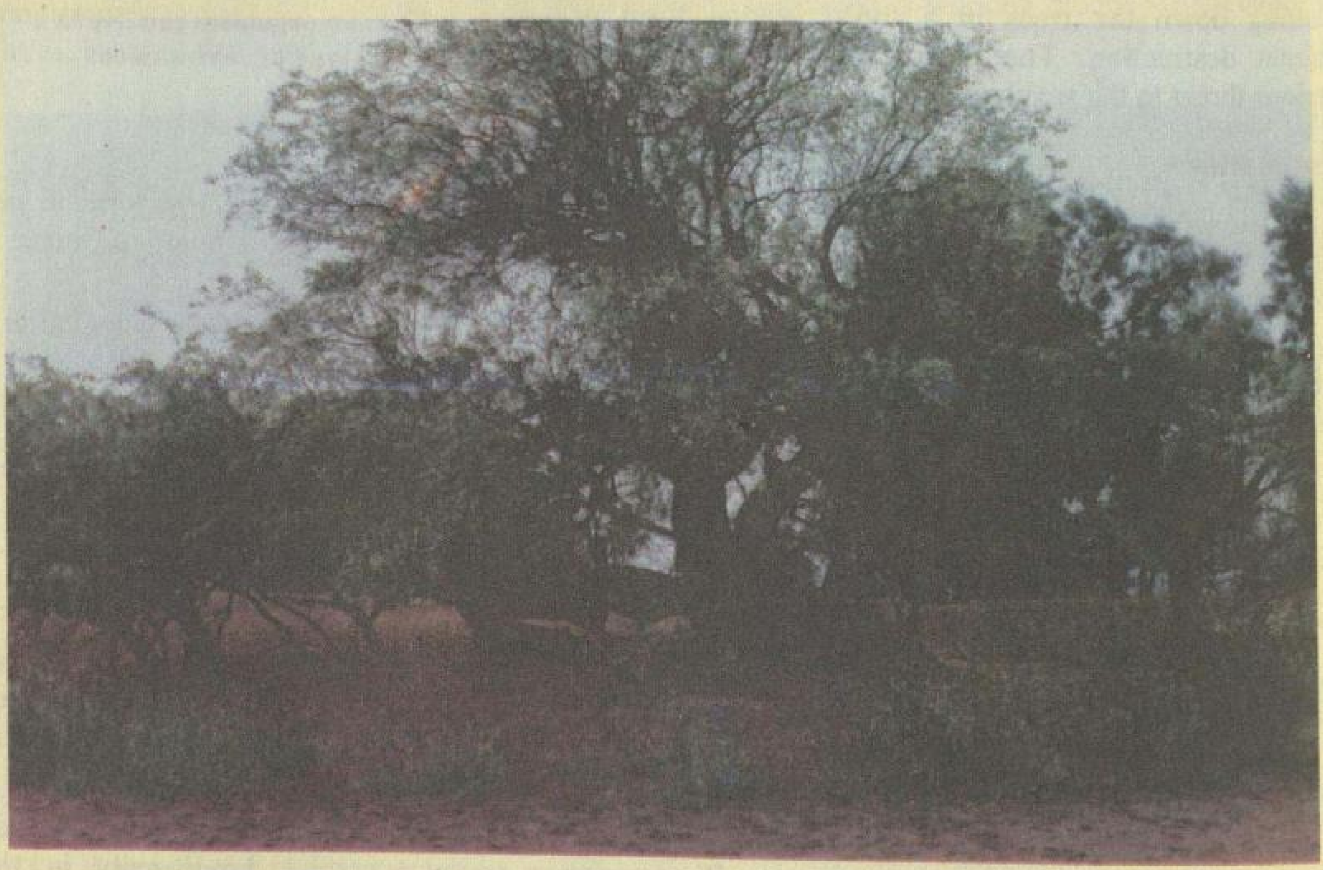


Fig. 19.5 ***Salvadora oleoides*** **(Wan, Peelu)**

The Biosphere

The biosphere is a global ecological system comprising all of earth's communities or ecosystems. In other words it is the largest ecosystem that comprises all the parts of the earth that support life. The biosphere reaches from the floor of the ocean to the tops of the highest mountains. All together, the biosphere is about 20 km (12.4 miles) thick. You may think that this sounds like quite distance, but the biosphere really makes up a thin layer surrounding the planet. If earth were the size of an apple, the layer that supports life would be only about as thick as the apple's skin.

19.3 Roles of Living Things (Biotic Components) in the Ecosystem

The organisms of most ecosystems obtain foods in three basic ways: producing, consuming, and decomposing.

19.3.1 Producers

Organisms that make their own food from inorganic molecules and solar energy are called producers. Plants are the most important producers in land ecosystems (Fig 19.6a). In an aquatic ecosystem, photosynthetic protists are the most important producers (Fig 19.6 b). Nearly all the energy entering the biosphere comes from the sun through photosynthesis.

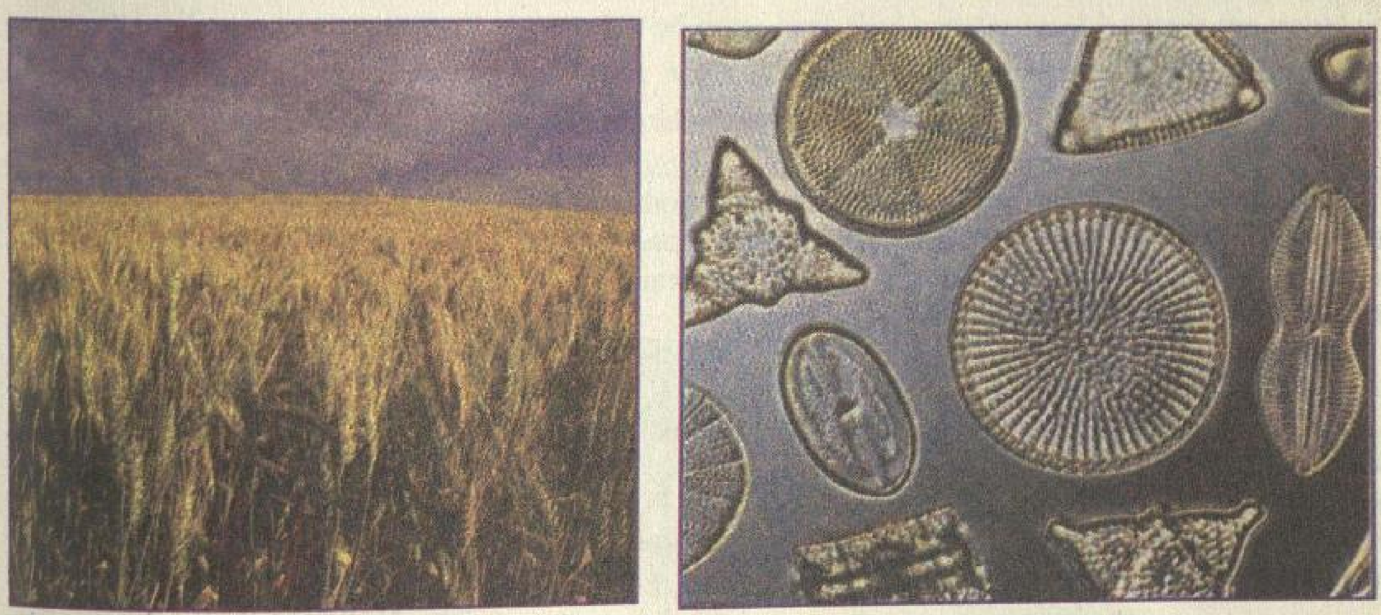


Fig. 19.6 Major producers in land ecosystems are plants (a). Diatoms are important producers in the oceans (b).

19.3.2 Consumers

Organisms that can not make their own food and use the food prepared by the producers are called consumers . All animals are consumers, as are fungi and many protists and many bacteria. Consumers obtain energy by ingesting other organisms or by absorbing food molecules. Consumers Consumers obtain energy by ingesting other organisms. Consumers obtain food in three basic ways.

Organisms that eat only plants are called **herbivores**. Because herbivores eat producers, they are also called **primary consumer**. Many insects and birds are herbivores, as are grazing animals such as cows, buffalos, goats and giraffes. The bodies of herbivores are adapted to gathering, grinding and digesting plants or other producers.

(a) (b) (c)

19.7 Consumers may be (a) herbivores (b) carnivores or (c) omnivores

Carnivores capture and eat herbivores or other carnivores. Carnivores that eat primary consumers are called **secondary consumers**, and those that eat other carnivores are called **tertiary consumers**. Lions, snakes, hawks, and spiders are examples of carnivores. The bodies of carnivores are adapted to hunting, capturing, and eating prey.

Some consumers, including human beings are **omnivores** that is, they eat both producers and other consumers. Omnivores act as primary, secondary, or tertiary consumers depending upon what they eat (Fig. 19.7).

19.3.3 Decomposers

Bacteria and fungi that consume the bodies of dead organisms and other organic wastes are called decomposers. They break down a variety of dead organic matter, from the fallen leaves of a tree to the bodies of herbivores and carnivores. Decomposers are crucial to the ecosystem because they recycle nutrients from the organisms back into the environment. Without decomposers, the producers in an ecosystem would quickly run out of nutrients.

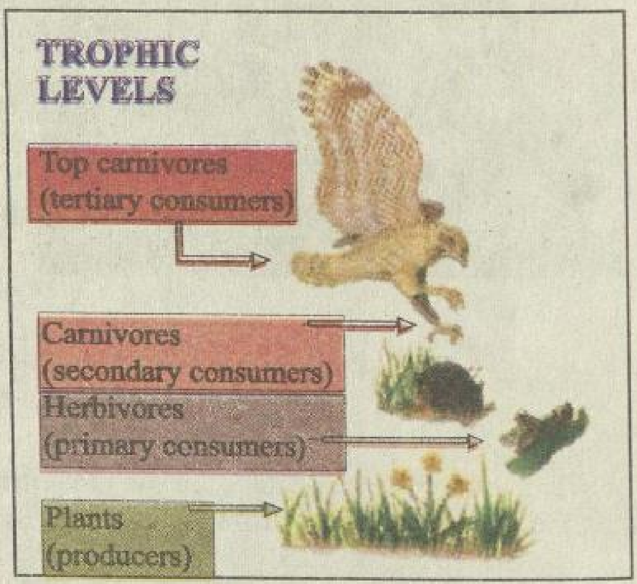

TROPHIC LEVELS
Top carnivores (tertiary consumers)
Carnivores (secondary consumers)
Herbivores (primary consumers)
Plants (producers)

Fig. 19.8 Energy flows when organisms eat one another. The organisms that obtain their energy from a common source constitute a trophic level.

Trophic Levels

The different feeding levels of organisms in an ecosystem are called **trophic levels**. Producers make up the first trophic level in all ecosystems. Because they make their own food, producers are called autotrophs. Autotrophs are the sole point of entry for new energy into the ecosystem.

Consumers form the second and higher trophic level in the ecosystem. Because they can not produce their own food and must obtain nourishment by eating other organisms, consumers are called heterotrophs. Primary consumers that eat producers form the second trophic level, and secondary consumers form the third trophic level. Omnivores and decomposers feed at all trophic levels. Most ecosystems have three, four, or five trophic levels. Each trophic level depends completely on the level below it (Fig. 19.8).

19.4 Flow of Materials and Energy within the Ecosystem

19.4.1 Food Chain and Food Web

The feeding relationships among organisms at different trophic levels form a chain, the food chain. A food chain may be defined as a series of organisms that transfer food between the trophic levels of an ecosystem. All food chains begin with producers, which are usually plants in land ecosystems. The food chain continues to herbivores at the next trophic level, followed by one or more levels of carnivores, the carnivores are consumed by decomposers. An example of a food chain is shown in (Fig. 19.9).

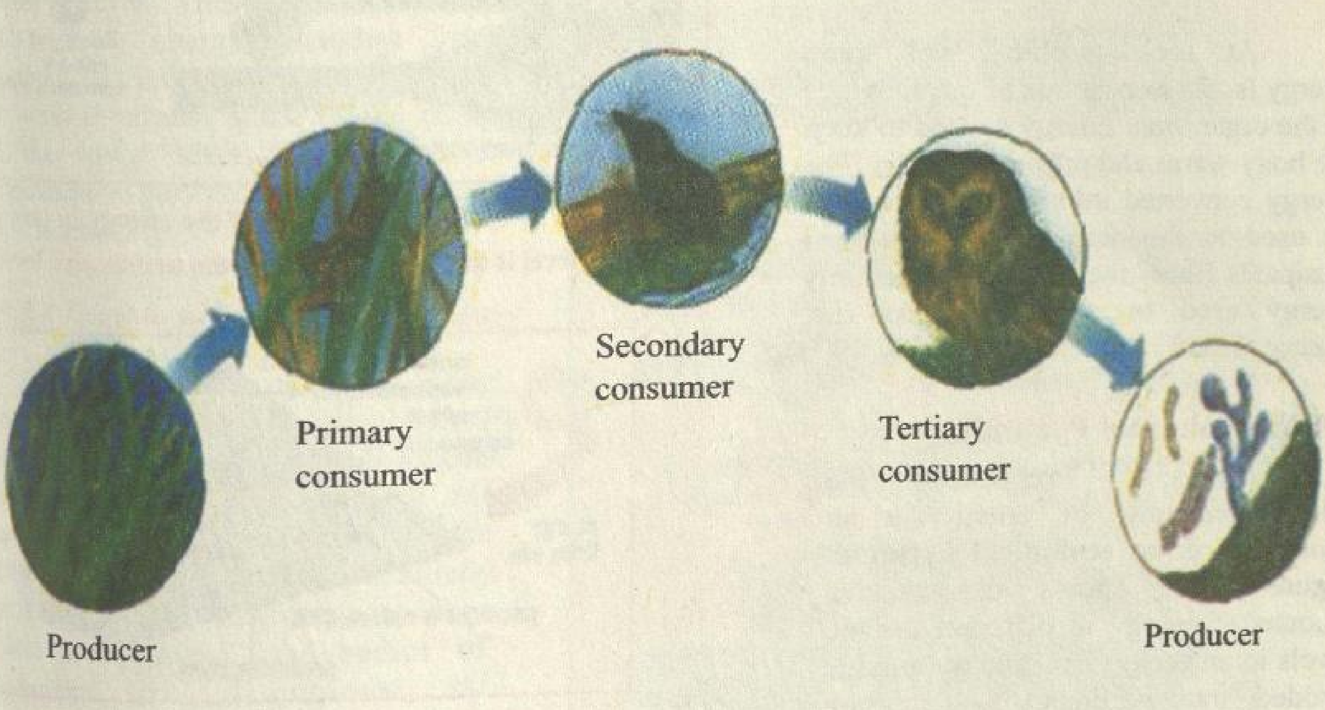


Fig. 19.9 A simple food chain

No ecosystem is simple enough to be represented by a single food chain or a few simple food chains. Most consumers feed on more than one type of food, and some consumers feed at more than one trophic level. A **food web** is a network of food chains representing the feeding relationships among the organisms in an ecosystems.

A food web includes all the food chains in an ecosystem. An example of a simple food web is shown in fig 19.10. It is important to note that changes in the population of an organism can affect many other populations.

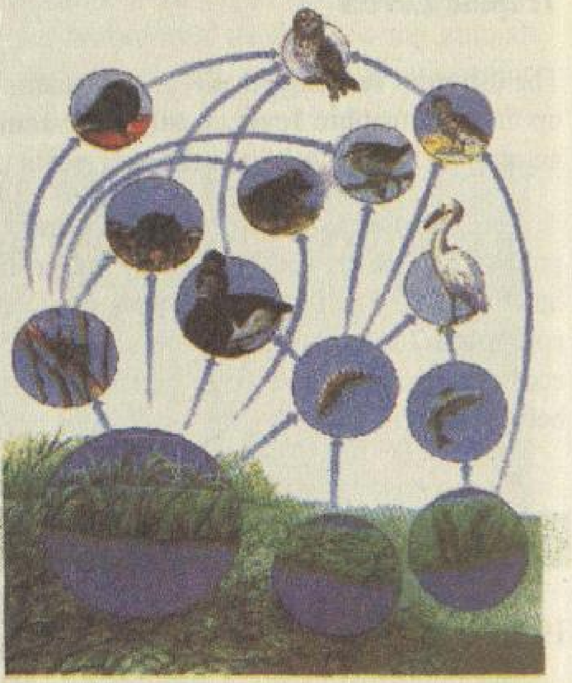


Fig. 19.10 A simplified food web for an aquatic ecosystem. In nature feeding relationship are not so simple.

19.4.2 Energy Flow

The passage of energy in a one way direction through the ecosystem is known as energy flow. In an ecosystem energy flow. occurs in food chains, in which energy from food passes from one organism to the next in a sequence.

Energy from the sun enters an ecosystem when producers use the energy (sunlight) to make organic matter through photosynthesis. Consumers take in this energy when they eat producers or other consumers. In this way energy moves on from one trophic level to the next.

At each trophic level some energy is lost as heat due to the activities of the organisms. Energy is used to keep the body warm and produce motion. The energy converted into heat form cannot be used in the next trophic level and dissipates into the atmosphere. Only energy used to make **biomass** (i.e. organic matter) remains available (Fig. 19.11).

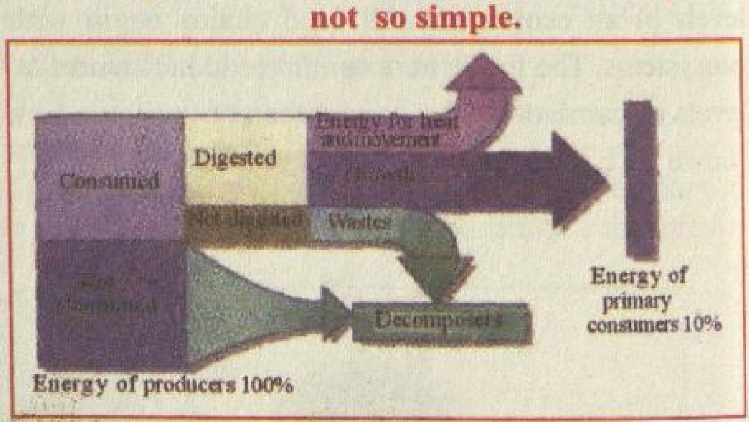

Energy for heat and movement
Consumed
Digested
Growth
Not digested
Wastes
Not consumed
Decomposers
Energy of primary consumers 10%
Energy of producers 100%

Fig.19.11 About 90 percent of the energy in one trophic level is lost before reaching the next trophic level

19.4.3 Ecological Pyramids

Ecologists represent the relative amounts of energy in an ecosystem in an **ecological pyramid.** Figure 19.12 shows the relative amount of energy in different trophic levels in an ecosystem. The pyramid is divided into sections, each section representing one trophic level. An ecological pyramid can show energy, biomass, or the number of organisms in a food web.

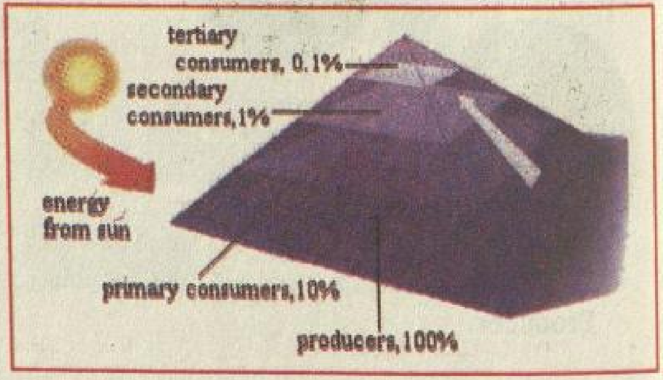

tertiary consumers, 0.1%
secondary consumers,1%
energy from sun
primary consumers,10%
producers,100%

Fig. 19.12 Ecological pyramids. How much of the energy that appears in one trophic level will appear in the next?

Pyramid of Numbers

A pyramid of numbers shows the number of organisms at each trophic level in a given ecosystem. In pyramids of numbers, each successive trophic level is occupied by fewer organisms. Thus, the number of herbivores (such as zebras and wild beasts) is greater than the number of carnivores (such as lions) (Fig. 19.13).

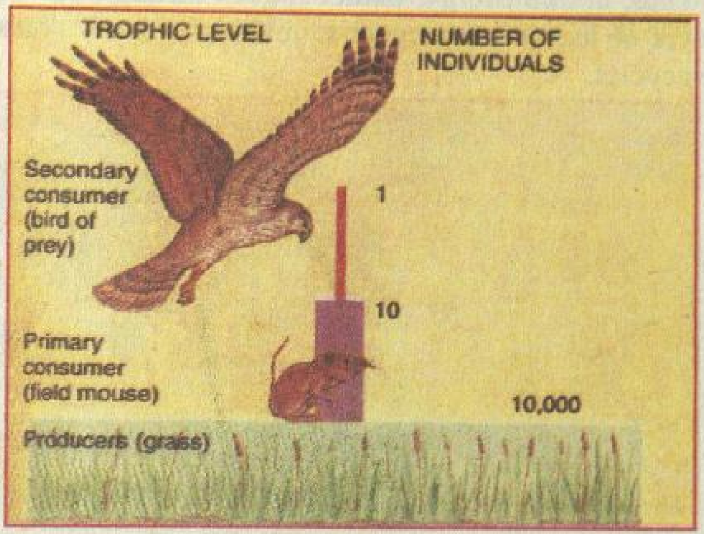

TROPHIC LEVEL
NUMBER OF INDIVIDUALS
Secondary consumer (bird of prey)
1
10
Primary consumer (field mouse)
10,000
Producers (grass)

Fig. 19.13 Pyramid of numbers

Pyramid of Biomass

A pyramid of biomass illustrates the total biomass at each successive trophic level. Biomass is the total amount of living matter at a trophic level. The pyramids of biomass show a progressive reduction of biomass in the successive trophic levels (Fig. 19.14).

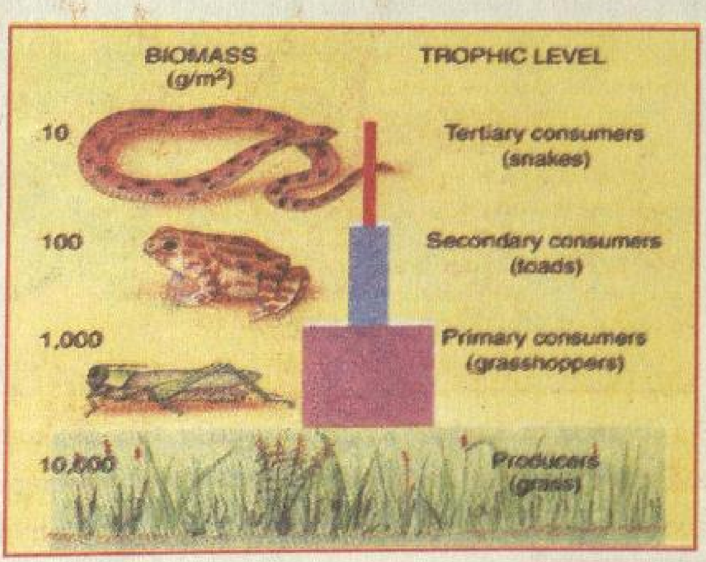

BIOMASS (g/m²)
TROPHIC LEVEL
10
Tertiary consumers (snakes)
100
Secondary consumers (toads)
1,000
Primary consumers (grasshoppers)
10,000
Producers (grass)

Fig. 19.14 Pyramid of biomass

Pyramid of Energy

A pyramid of energy indicates the energy content in the biomass of a trophic level. These pyramids show that less energy reaches each successive trophic level from the level beneath it because some of the energy at the lower level is used by the organisms to perform work, while some of it is lost (Fig. 19.15)

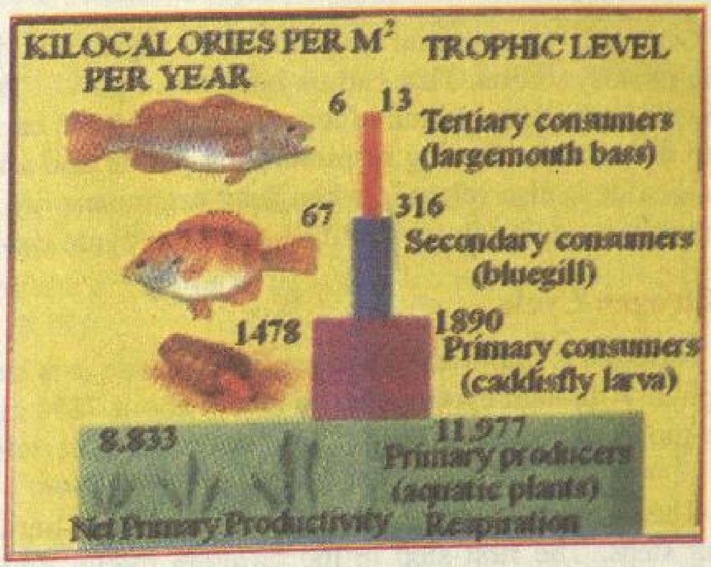
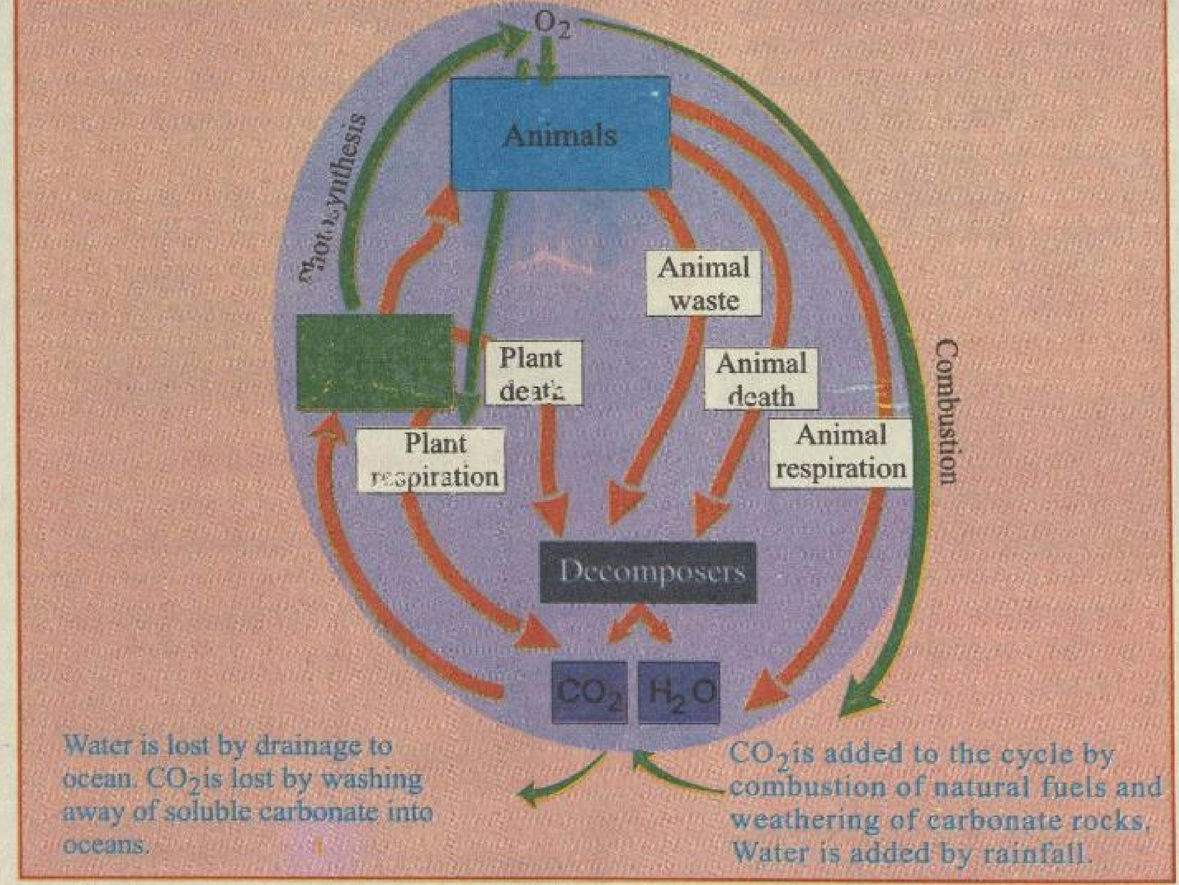

KILOCALORIES PER M² PER YEAR
TROPHIC LEVEL
6
13
Tertiary consumers (largemouth bass)
67
316
Secondary consumers (bluegill)
1478
1890
Primary consumers (caddisfly larva)
8,833
11,977
Primary producers (aquatic plants)
Net Primary Productivity
Respiration

Fig. 19.15 Pyramid of energy

19.4.4 Cycling of Materials in Nature

The chemicals found in living organisms are derived originally from the abiotic components of ecosystems such as soil, water, air. These materials are cycled through the ecosystems and are eventually returned to the environment when waste products and dead bodies of organisms are decomposed by bacteria and fungi. They are available for reuse by organisms.

Thus, unlike energy, matter moves through the ecosystem in cycles. The amount of matter that enters or leaves each cycle is relatively small. This fact is illustrated by carbon, water, and nitrogen cycles.



Water is lost by drainage to ocean. CO_2 is lost by washing away of soluble carbonate into oceans.

CO_2 is added to the cycle by combustion of natural fuels and weathering of carbonate rocks. Water is added by rainfall.

Fig 19.16 The Carbon cycle. Naturally the amount of carbon dioxide used in photosynthesis and released in respiration and decomposition is balanced. However, greater amount of carbon dioxide has been added to the atmosphere by human activities. Do you know how? What may be its conseqeunces?

The Carbon Cycle

Carbon is an essential constituent of organisms. Carbon from carbon dioxide is utilized by plants in photosynthesis. This carbon becomes a part of the food made by them. The green plants are eaten by the herbivores, which in turn are eaten by the carnivores. Thus carbon is transferred from the plants to the animals. During respiration by plants and animals, CO_2 is released into the atmosphere. Carbon dioxide is also released when dead organisms are decomposed by the decomposers. From the atmosphere it is again returned to the plants and cycle continues (Fig. 19.16)

The Nitrogen Cycle

Nitrogen is important for organism because it is an essential part of proteins, nucleic acids and chlorophyll. Although earth's atmosphere is about 78% nitrogen gas (N_2) but organisms are unable to use this molecular nitrogen unless it is converted to certain compounds (such as nitrates)

The nitrogen cycle, in which nitrogen cycles between the abiotic environment and organisms has four steps. The first step in the nitrogen cycle, which is called **Biological Nitrogen Fixation**, involves the conversion of gaseous nitrogen (N_2) to ammonia. Biological fixation is carried out by the activity of nitrogen fixing bacteria in the soil and aquatic environment. Some nitrogen fixation to nitrates also occurs by combustion, volcanic action, lightening discharges and industrial means.

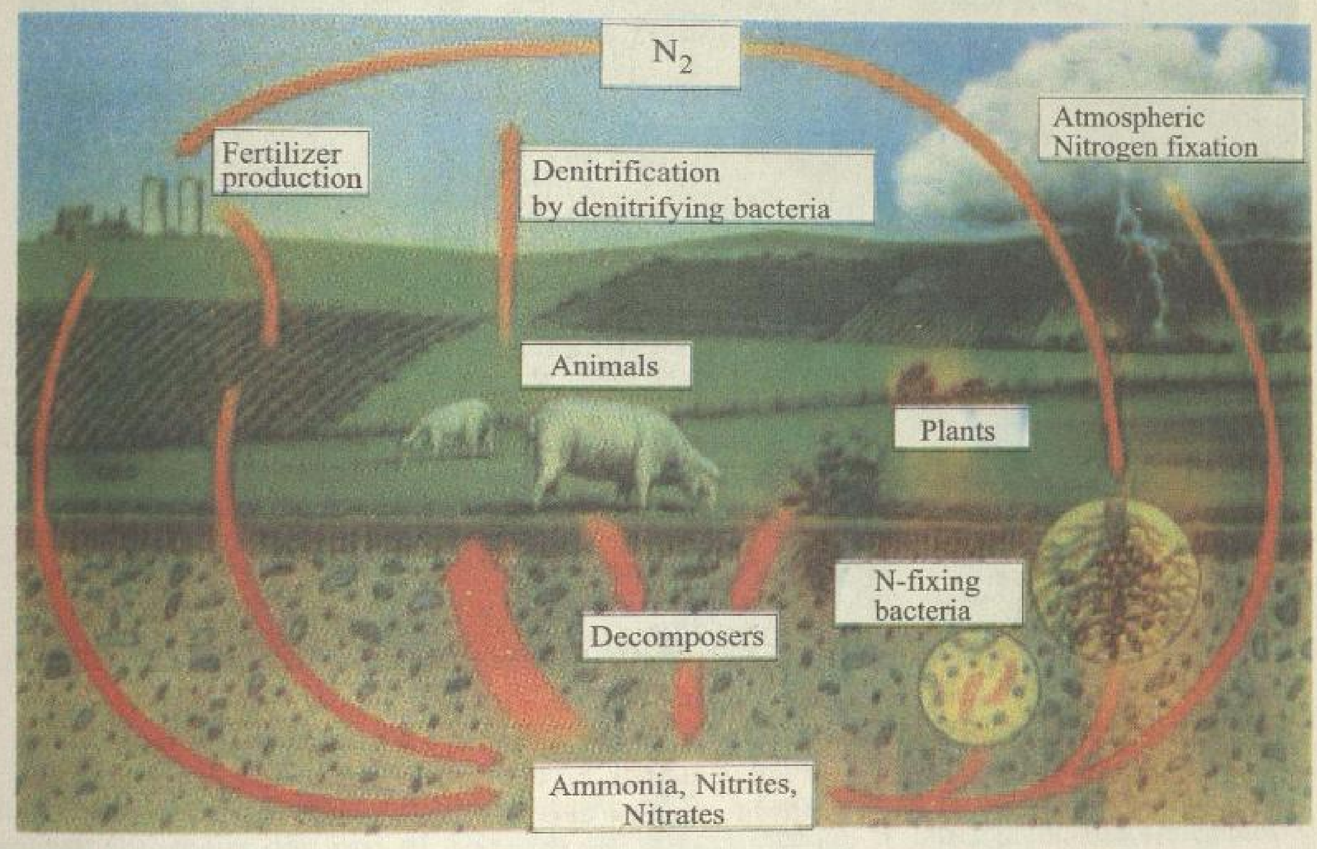

N_2
Fertilizer production
Denitrification by denitrifying bacteria
Atmospheric Nitrogen fixation
Animals
Plants
N-fixing bacteria
Decomposers
Ammonia, Nitrites, Nitrates

Fig. 19.17 The nitrogen cycle. All nitrogen originally comes from the atmosphere

The second step of the nitrogen cycle is **Nitrification**. It involves the conversion of ammonia (NH_3) to nitrates. Nitrification is also accomplished by bacteria.

In the third step, called **Assimilation**, plants through the roots absorb ammonia or nitrates and incorporate the nitrogen into proteins, nucleic acids and chlorophyll. When animals consume plant tissues, plant nitrogen compounds are converted to animals nitrogen compounds forming the bodies of animals.

The fourth and final step of the nitrogen cycle is **Denitrification**. During this stage nitrogen containing wastes and dead bodies of organisms are decomposed to ammonia and nitrates. The nitrates are reduced to gaseous nitrogen by the action of denitrifying bacteria. Gaseous nitrogen thus produced escapes to the atmosphere (Fig 19.17)

The Water Cycle

Water continuously circulates from the oceans to the atmosphere, to the land and back to the ocean. Water evapourates from the ocean surface and from soil, streams, rivers, and lakes in the form of water vapours.

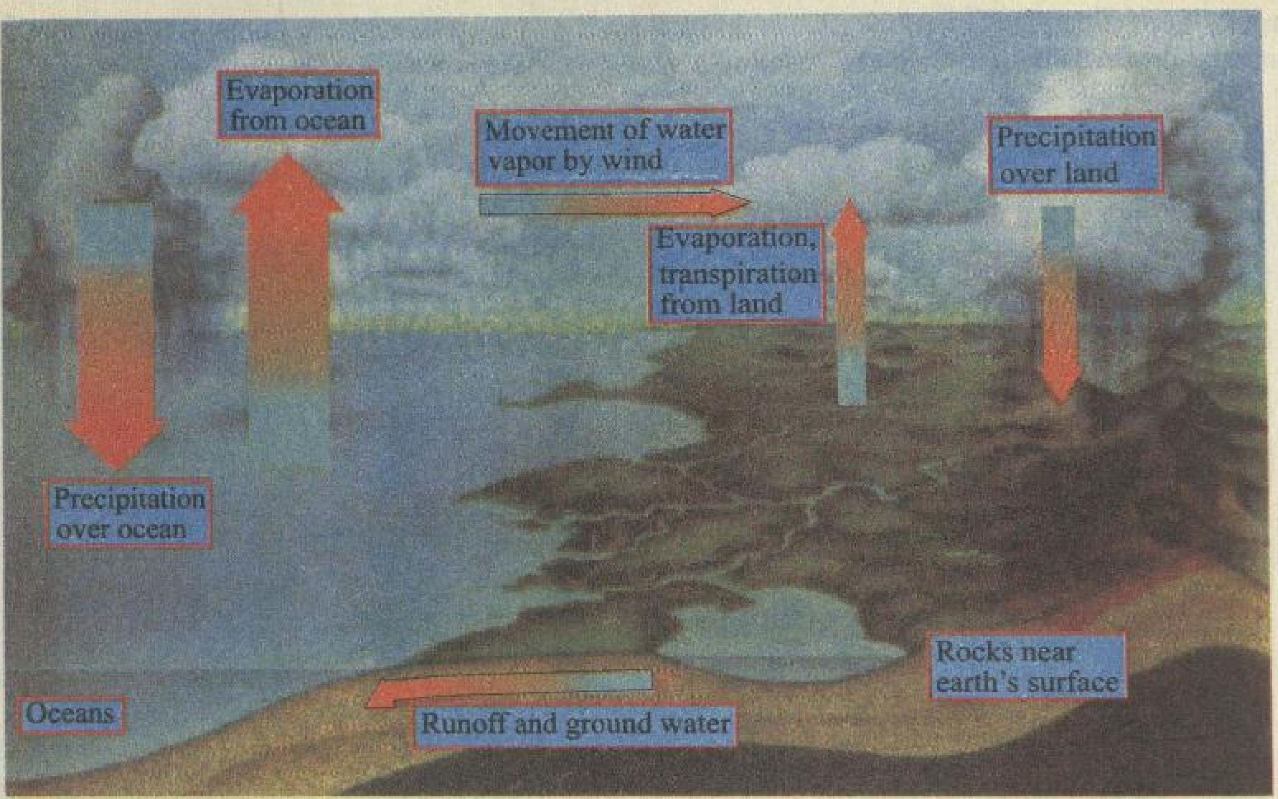

Evaporation from ocean
Movement of water vapor by wind
Precipitation over land
Evaporation, transpiration from land
Precipitation over ocean
Rocks near earth's surface
Oceans
Runoff and ground water

Fig. 19.18 The water cycle. Most of the earth's surface water is stored in the oceans. Only about 2 percent present in the fresh lakes, ponds, rivers and streams, and in the form of precipitation (rain and snow) is available for our everyday and industrial use.

In addition, transpiration by plants adds a considerable amount of water vapour to the atmosphere. The water vapour in the atmosphere condenses and forms clouds. It eventually comes down to the land and oceans in the form of precipitation (rain, dew, snow, or hail). Water may evapourate from land and re-enter the atmosphere directly. Alternately, it may flow in rivers and streams as run off water, reaching the ocean. Some water percolates downward in the soil to become ground water. Ground water remains in the ground for hundreds to many thousands of years, but eventually it supplies water to the soil, to streams and rivers, to plants, and to the ocean (Fig 19.18).

19.5 Balance in Nature

An ecosystem is a self-sustaining system. Except for energy (light) it does not require any thing from outside. The system is capable of maintaining itself because of the delicate but complex interactions of its biotic and abiotic components, as illustrated by food webs and natural cycles. Like the human body, the ecosystem has different parts that perform different functions, each crucial to the survival of the whole.

All natural ecosystems are stable. They maintain a state of balance, called equilibrium. If ecosystems are not balanced, they do not survive. An ecosystem gets this stability from the maze of interactions that link its parts. A disruption in one part of the ecosystem, such as a temperature change to a colder climate, is counteracted by changes in other parts of the ecosystem, such as the evolution of adaptation to cold weather. The disrupted ecosystem returns to a state of equilibrium.

Major disruptions cause dynamic changes as the ecosystem adjusts to the new conditions. Some disruptions can destroy whole ecosystems. But a new ecosystem will develop to replace the one destroyed (Fig 19.19).

Fig. 19.19 Cutting of forests is one form of disrupting the environment and interfering with habitats.

It is very difficult to understand every detail of how even simple ecosystems function. We understand that changes in one part of a system can trigger changes in other parts. But we cannot always predict how changes in one part of the ecosystem will affect another part.

At present, species are becoming extinct at the fastest rate since earth's known history. The cause of these extinctions is human activity. Humans are also placing many other stresses, such as pollution and deforestation, on global environment without knowledge of the consequences and how will the consequences affect future generations and the global ecosystem in which they live?

19.6 Ecological Interdependence of Organisms

Organisms in ecological communities interact with one another in four major ways.

1. One organism, by its activities, may benefit itself while harming the other. For instance, individuals of one species may kill and eat individuals of other species (predator-prey interaction). One type of individuals may obtain their food from the other but may or may not kill it (host-parasite interaction).
2. Two organisms may mutually harm one another. This type of interaction is common when two organisms use the some resources and the resources are insufficient to supply their combined needs. Such organisms are called competitors, and their interaction constitute competition.
3. Individuals of two species may develop an intimate, long-term relationship or association (symbiosis). In symbiosis, both participants may benefit from an interaction (multualism); or one participant benefits and the other is unaffected (commensalism); or one participant benefits and the other is harmed (parasitism).

19.6.1 Predation

Consumers that actively hunt other organisms are called predators. The organisms upon which a predator feeds are called prey. A frog that eats an insect is a predator. The insect is the prey. The frog itself is prey to other organisms such as snakes and storks. The predators, in turn, become prey to larger carnivores (Fig 19.20).

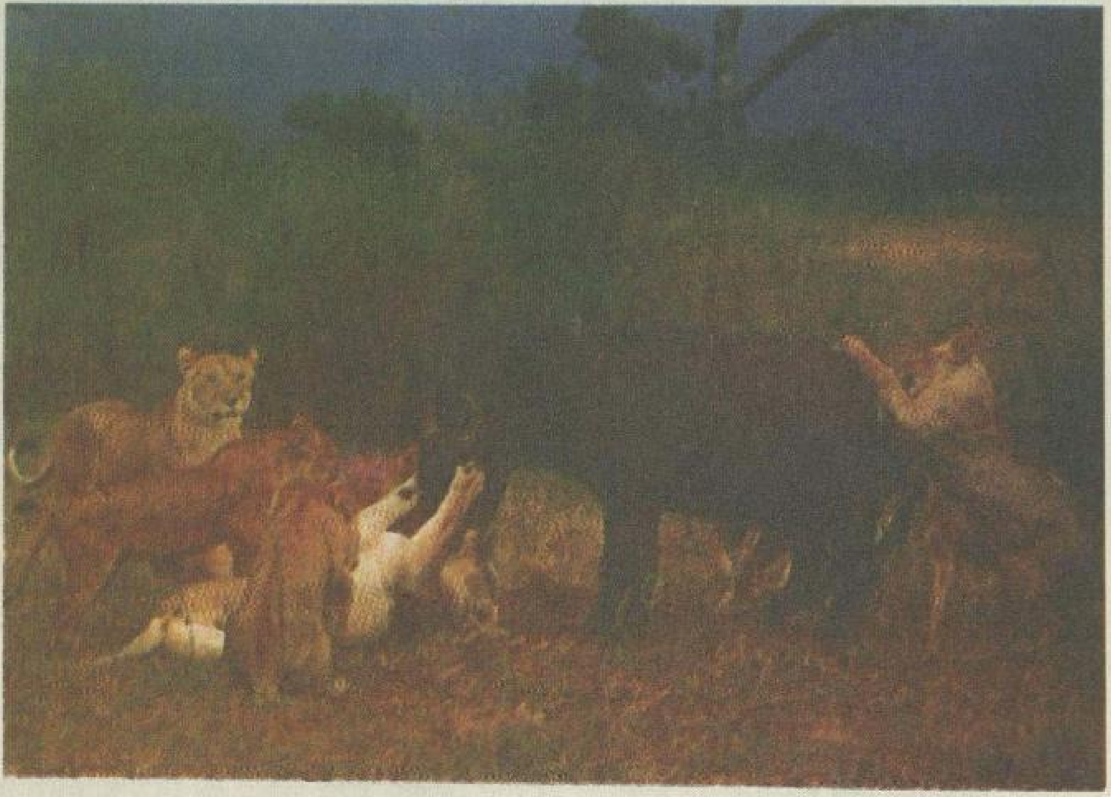


Fig. 19.20 Predators actively hunt and kill their prey

The size of predator and prey populations are closely linked. A large prey population can support more predators than small prey population. If a prey population grows or shrinks, the number of predators changes as well.

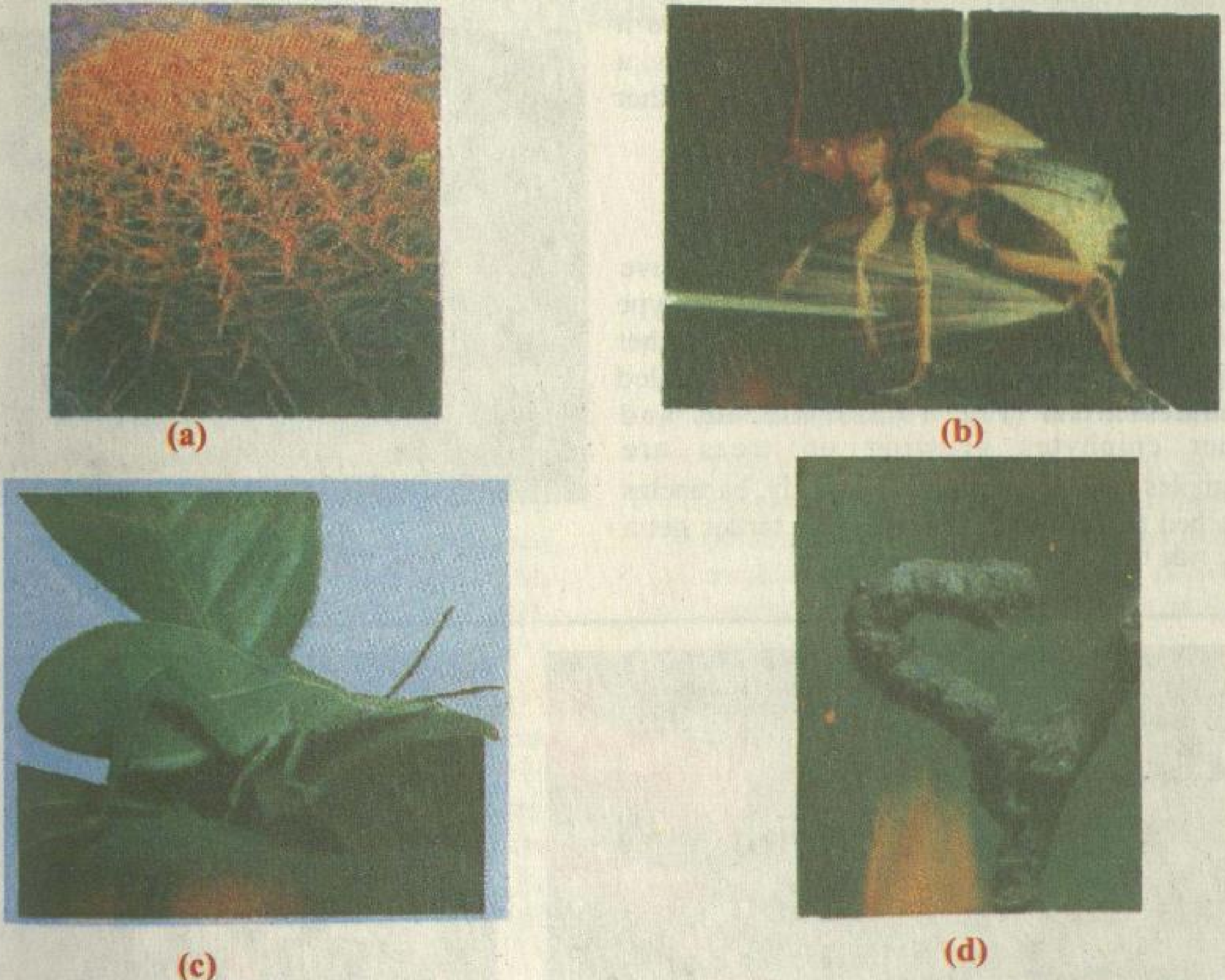
19.6.2 Symbiosis

The intimate and log-term relationship between two organisms is called symbiosis. It is of three types i.e. parasitism, mutualism and commensalism.

Some organisms do not kill the organism they feed on. **Parasitism** is a type of symbiotic relationship in which an organism feeds on the tissues or body fluids of another. The organism on which a parasite feeds is called the host. A parasite is harmful to its host and may even be fatal. Most parasites, however, do not kill their hosts. Examples of parasites are fleas, ticks, lice, a variety of worms, protists, many bacteria, and all viruses.

A true parasite is adapted to living on or in the body of its host. A parasite depends on its host for many functions. Many parasites cannot perform functions that the host provides for them.

The population size of a parasite is closely related to the population of its host. A large host population can support more parasites than a small host population. Parasite populations are also affected by the density of the host population. Parasites thrive in crowded host populations because the parasite can find new hosts easily.



(a) (b) (c) (d)

Fig. 19.21 As a consequence of predator-prey interactions, prey have evolved a rich variety of adaptations that make them difficult to be captured and eaten. Some of the evolutionary adaptations are toxic hair, bristles or tough spines (a), obnoxious chemicals (b), camouflage (c), and mimicry (d).

19.6.3 Competition

Competition occurs when two or more individuals attempt to use essential common resource such as food, water, shelter, living space or sunlight. Because resources are often in limited supply in the environment, their use by one or more individuals or populations decreases the amount available to others.

Competition can occur among individuals within a population, the **intraspecific competition**, or between different species, the **interspecific competition**.

Intraspecific competition may result in:

1. reduced growth and reproductive rates for some individuals,
2. exclude some individuals from better environments,
3. cause the death of some individuals due to non-availability of resources.

Interspecific competition affects individuals in the some way, but in addition, an entire species may be excluded from habitats where it cannot compete successfully. In extreme cases, a competitor may cause extinction of another species.

19.6.4 Mutualism and Commensalism

A relationship where two species live together closely is called symbiosis and the type of symbiosis that benefits one species and neither helps nor harms the other is called **commensalism** (Fig. 19.22). Lichens and other epiphytes growing on trees are examples of commensalism. Similarly, barnacles attached to the backs of whales and turtles get a free ride to better feeding places.

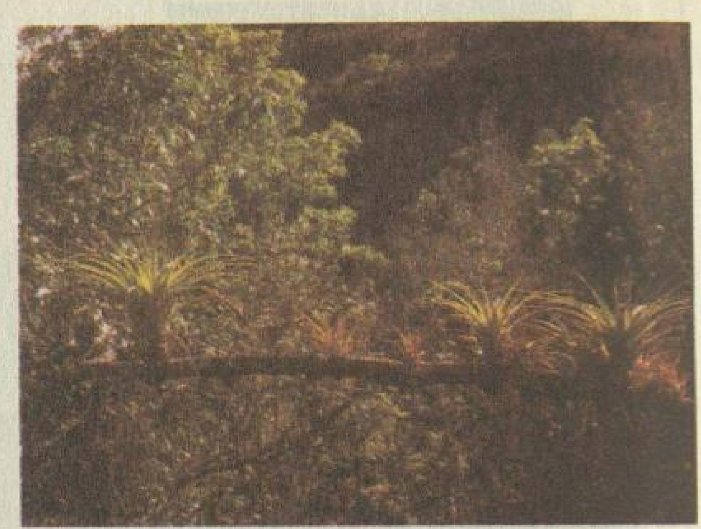
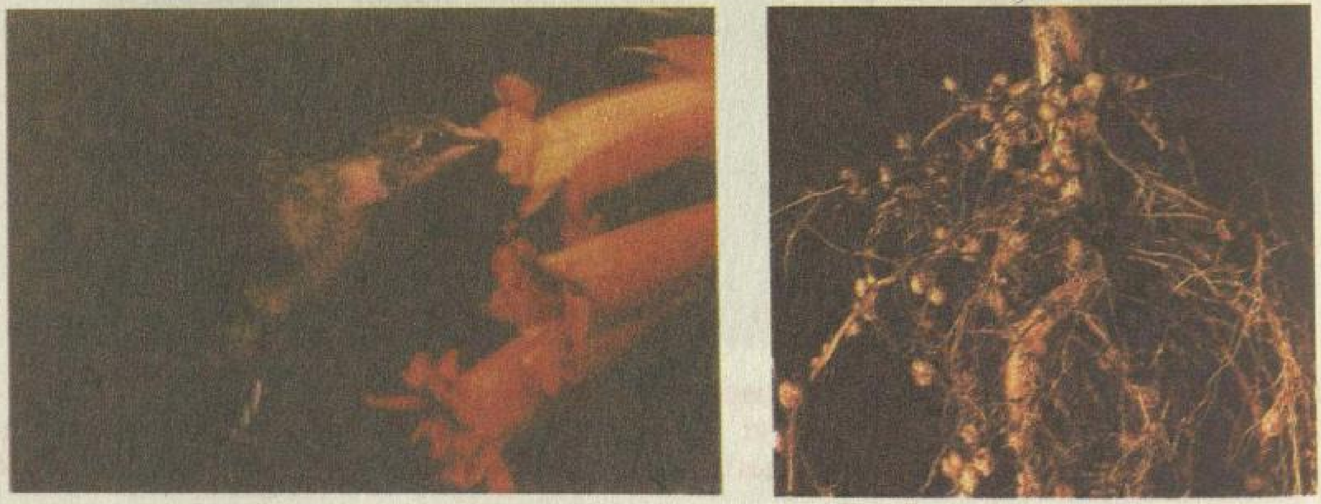


Fig. 19.22 Commensalism



(a)

(b)

Fig. 19.23 Mutualism

A symbiotic relationship in which both species benefit is called **mutualism**. An example is the relationship between flowers and the insects that pollinate them. The flower provides the insect with food in the form of nectar, and in return, the insect fertilizes the flower. Zooflagellates living in the guts of termites is another example of mutualism. The zooflagellates secrete enzymes to digest cellulose, which termite cannot do. The zooflagellates in return absorb prepared food from the gut. Mycorrhizae, lichens and nitrogen-fixing bacteria in the root nodules of leguminous plants (Fig. 19.23) are other examples of mutualism.

KEY POINTS

1. An organism obtains all the requirements of life (food, shelter etc) from its environment. The survival of organism may become difficult if the conditions in the environment change.
2. An environment is an interplay of all living (biotic) and non-living (biotic) factors. Organisms are affected by the changes in the environment, and in turn bring changes in the environment.
3. Interactions among organisms and between organisms and their physical environment result in the establishment of an organised ecological system or ecosystem. All ecosystems are self-sustaining and self-regulatory. So, ecosystems are naturally balanced and possess equilibrium.
4. Changes in one part of the ecosystem lead to changes in some other part (s) of the ecosystem. If disruptions are not catastrophic, they are overcome and the ecosystem returns to its original state. An ecosystem may not be able to bear and absorb large disruption. New ecosystems will replace the old ones.
5. Materials and energy flow through the ecosystem as expressed by food chains, food webs and natural cycles. Flow of material in an ecosystem is cyclic, very few materials enter or leave the ecosystem. One the other hand flow of energy is in one direction only, entering only at the producers level.
6. The relative amount of energy in an ecosystem is represented by ecological pyramids. Less energy reaches a particular trophic level than the level below it. Some energy is lost in the form of heat at each trophic level.
7. Ecological interdependence of organisms results in predator-prey, host-parasite, competative, and symbiotic relationships.
8. Unpleasant changes in the biosphere are occurring at an unprecedented and faster rate than ever before due to human activity; leading to environmental degration, pollution and species extinction.

QUESTIONS

1. **Fill in the blanks.**

(i) The total amount of the organic matter in a trophic level is called the ________.

(ii) The study of relationships of organism and their environment is called ________.

(iii) All non-living parts of the environment such as water, light, temperature etc are called ________.

(iv) The type of environment in which a particular species lives is called its ________.

(v) Total number of individuals of a species living together in the same area at particular time constitute ________ of that species.

(vi) The biosphere is about ________ Km thick.

(vii) Depending upon what they eat, the ________ may be primary, secondary or tertiary consumers.

(viii) The different feeding levels of organisms in an ecosystem are called ________.

(ix) Omnivores and ________ feed at all trophic levels.

(x) The flow of materials in an ecosystem is ________ and the flow of energy is ________.

(xi) All natural ecosystems are balanced and they maintain a state of balance, called ________.

(xii) Competition occurring among individuals within a population is called ________.

2. Each question is followed by four options. Encircle the correct answer.

(i) All the members of a species that live in an area make up;
(a) an ecosystem (b) a habitat
(c) a population (d) a community

(ii) Habitat destruction can result in a loss of;
(a) species (b) community
(c) land (d) ecosystem

(iii) Organisms that make their own food with help of sunlight, CO_2 and H_20 are called;
(a) consumers (b) producers
(c) decomposers (d) predators

(iv) The lowest trophic level of an ecosystem always includes;
(a) herbivores (b) carnivores
(c) producers (d) consumers

(v) A network of all the feeding relationships in an ecosystem is called;
(a) a food chain (b) a food web
(c) a trophic level (d) energy flow

(vi) Sunlight, temperature, air and water are examples of;
(a) biotic factors
(b) a biotic factors
(c) nutrients
(d) mineral resources

(vii) An organism that actively hunts other organisms is called a;
(a) herbivore (b) consumer
(c) predator (d) parasite

(viii) A relationship between species in which one species benefits and the other is harmed is called;
(a) symbiosis (b) commensalism
(c) parasitism (d) predation

(ix) A relationship between species in which both species benefit is called;
(a) parasitism (b) mutualism
(c) symbiosis (d) commensalism

(x) If a disturbed ecosystem goes out of balance and cannot return to a state of equilibrium, the species living there will;
(a) move to other places
(b) find new resources
(c) become extinct
(d) face no problem

(xi) A community and its biotic environment constitutes a (an);
(a) biosphere (b) habitat
(c) ecosystem (d) food web

(xii) Which of the following processes increases the amount of atmospheric carbon in the carbon cycle?
(a) photosynthesis
(b) cellular respiration
(c) combustion
(d) both a and b
(e) both b and c

(xiii) In the nitrogen cycle, gaseous nitrogen is converted to ammonia by;
(a) assimilation (b) nitrification
(c) assimilation (d) denitrification
(e)

(xiv) The conversion of ammonia to nitrates is carried out by soil bacteria. This process is called;
(a) ammonification
(b) nitrification
(c) denitrification
(d) nitrogen fixation
(e)

(xv) A relationship between organisms in which individual of one species may kill and eat individuals of other species is called;
(a) symbiosis (b) competition
(c) predation (d) mutualism
(e)

4. Give the short answers to the following questions.

(i) Define the following terms.

- (a) competition
- (b) symbiosis
- (c) predation
- (d) assimilation
- (e) biological nitrogen fixation
- (f) biomass
- (g) food web
- (h) trophic levels
- (i) habitat
- (k) community.

(ii) Name the fields of study ecology deals in.

(iii) What is meant by habitat? What consequences may be expected if habitat of a species is destroyed?

(iv) What is the importance of decomposers in an ecosystem?

(v) What type of organisms always constitute the lowest trophic level in any ecosystem?

(vi) Write down in sequence the four steps in the nitrogen cycle.

(vii) How does predator prey relationship affect populations?

4. Explain competition. What are affects of competition on species and communities?

5. Discuss symbiotic relationships with examples.

6. Describe different types of interactions among ecological communities.

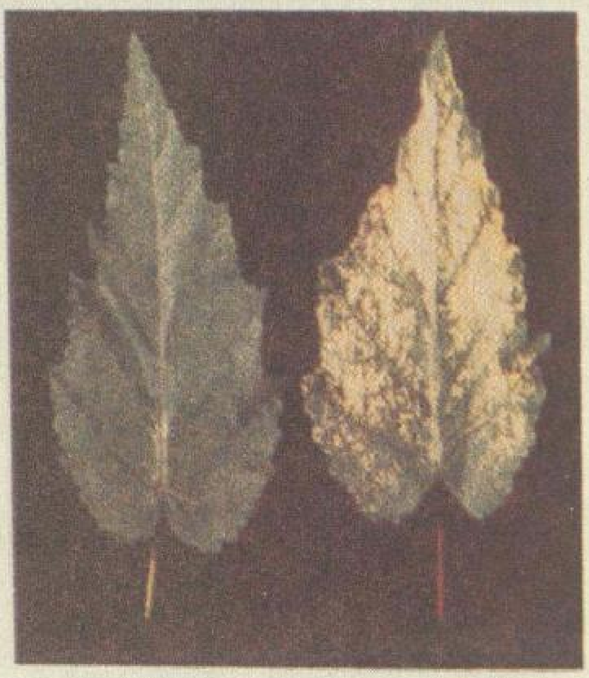
7. Write a brief essay on balance in nature, emphasising man's role in disturbing this balance.

8. What are ecological pyramids? What do they tell us about flow of materials and energy between different trophic levels?

9. Describe ecological roles of producers, consumers and decomposers.

MAN AND BIOLOGY

- **In this chapter you will learn:**
- Definition and process of Biotechnology and Genetic Engineering.
- Role of Biology in the economic development of various aspects of human life.
- Biological control of pests.
- Definition, source and control of pollution.
- Role of Biology in the conservation of environment.
- Organisms effecting human health and some common diseases.
- Some insects as vectors of diseases.



Man is a social animal. His demands and problems are increasing day by day. To cope with these demands biologists are investigating day & night. They have introduced many new techniques and technologies, which are proving helpful in solving the problems originated by over population, pollution and microbes.

20.1 Genetic Engineering and Biotechnology

Genetic Engineering is a technique used to transfer useful genes from one organism to another for attaining a specific benefit for mankind. You have already studied it in detail in chapter 17.

20.1.1 Transgenic Bacteria and the preparation of Insulin

One of the proteins formed by the process of genetic engineering is Insulin. Insulin is a hormone produced by our bodies, which control the amount of sugar in the blood. People, unable to make insulin suffer from the disease "diabetes mellitus". They are unable to store glucose as glycogen but excrete it in their urine. Insulin is used to treat such patients. Insulin produced by genetic engineering is exactly the same as ordinary human insulin.

Any organism which acquires a foreign gene is called Transgenic organism.

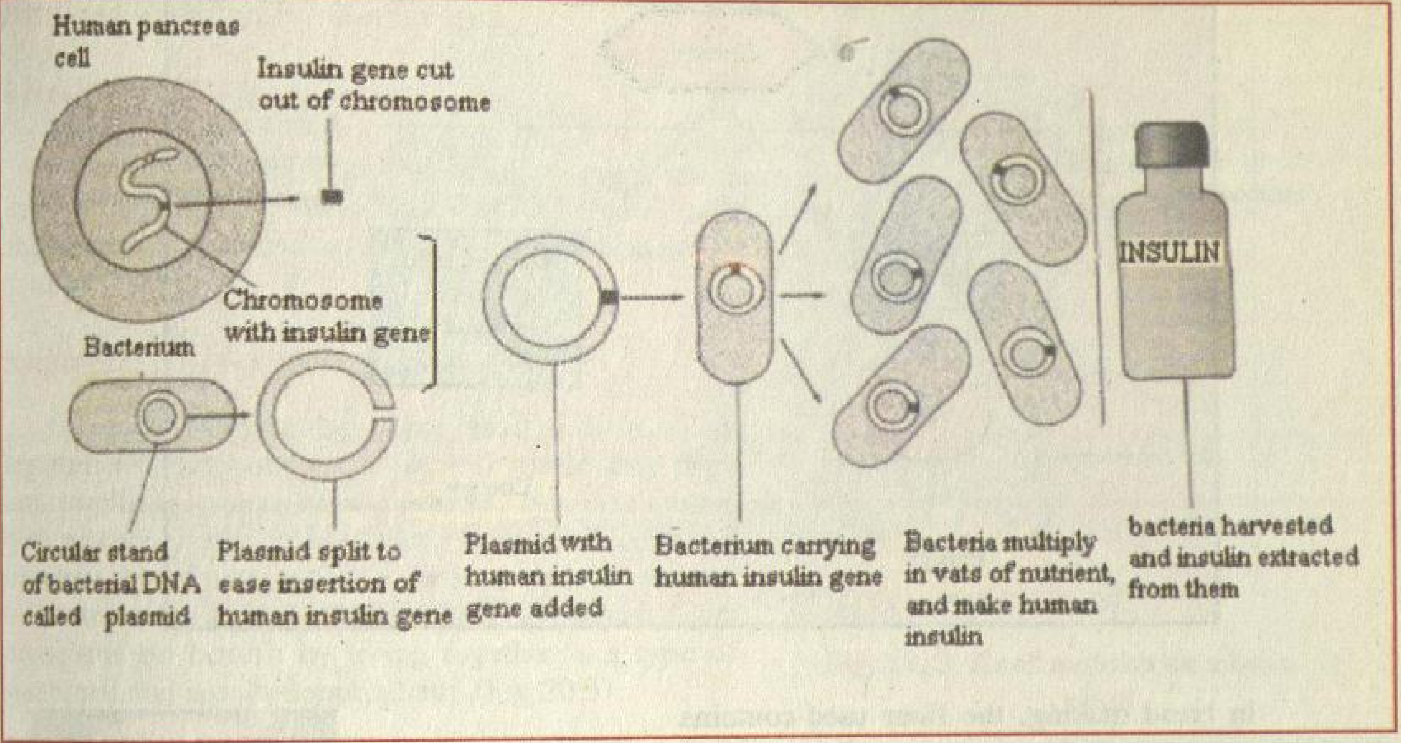

Human pancreas cell
Insulin gene cut out of chromosome
Chromosome with insulin gene
Bacterium
INSULIN
Circular stand of bacterial DNA called plasmid
Plasmid split to ease insertion of human insulin gene
Plasmid with human insulin gene added
Bacterium carrying human insulin gene
Bacteria multiply in vats of nutrient, and make human insulin
bacteria harvested and insulin extracted from them

Fig. 20.1 The introduction of human gene into a bacterium abd production of insulin

Genetic Engineering is of great importance and has application in agriculture, chemical & drug industries and medicine.

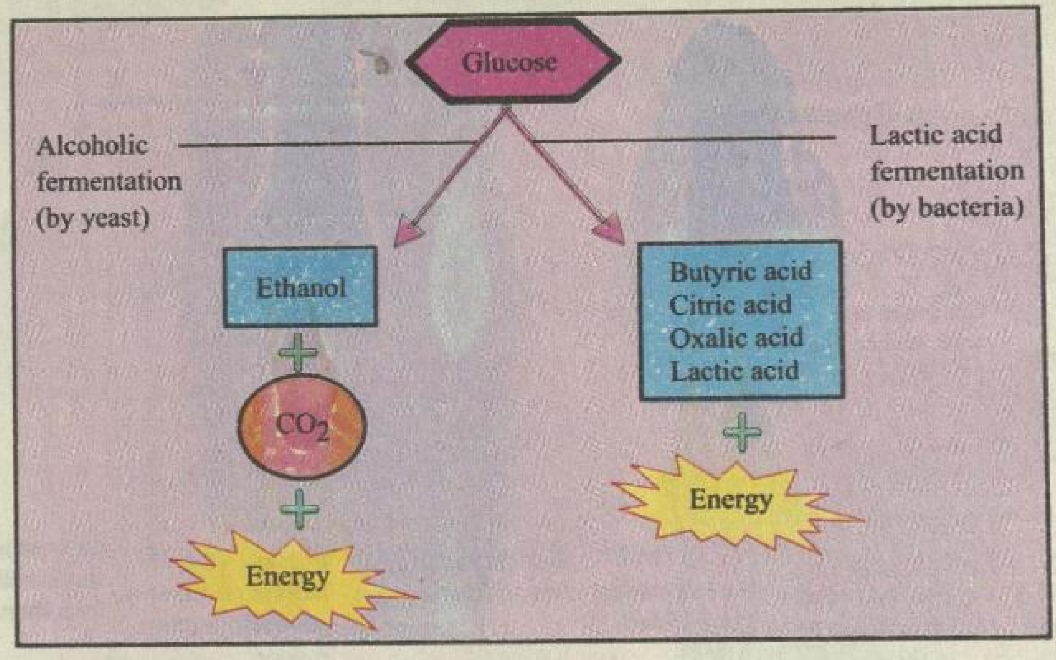
20.1.2 Biotechnology

Biotechnology is a large-scale industrial use of biological processes of microorganisms to make substances useful for mankind. The term 'Biotechnology' was introduced in 1970's. Biotechnology is usually linked to genetic engineering and is involved in the production of specific products (e.g. enzymes and hormones) by genetically engineered organisms (Fig.20.1).

The ability of microorganisms to carry out fermentation has long been used to produce foods such as bread, cheese and yogurt. Some other examples of the use of biotechnology are production of antibiotics, single cell proteins and fertilizers.

Fermentation

It is a catabolic process in which partial degradation of sugar occurs without the help of oxygen. Lactic acid fermentation by certain fungi and bacteria is used in the diary industry to make cheese and yogurt. Alcoholic fermentation is the second type of fermentation. Acetone and methyl alcohol are the by-products of this fermentation. These are commercially important. In baking industry brewing is carried out by yeast.



In bread making, the flour used contains starch, protein and an enzyme amylase. Yeast added in the flour. The flour is mixed with water to form dough. Amylase digests the starch into glucose. Lack of O_2 inside the dough causes the yeast to respire anaerobically. As a result glucose is fermented to alcohol and CO_2The CO_2 produced causes the dough to rise and because of this, cavities appear. Alcohol produced evaporates during baking (Fig 20.2).

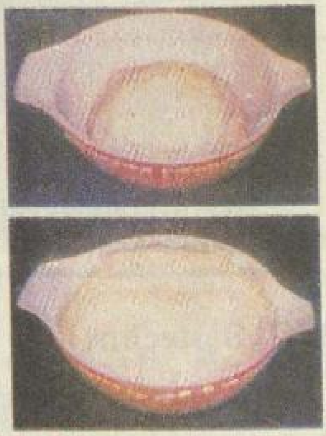


Fig 20.2 CO_2 produced by the yeast causes dough to rise

20.2 Role of Bacteria and Fungi in Decomposition

Decomposers are saprophytes which feed on faeces and dead organisms. Many bacteria and fungi are decomposers. They secrete enzymes onto their food. These enzymes break down complex organic compounds of the food like carbohydrates and proteins in simpler components with the release of energy. Decomposers absorb only a small amount of energy and nutrients thus produced for their own use. Most of the energy is lost as heat and the remaining materials are released into the surrounding soil, air and water.

The inorganic compounds released during decomposition include gases like CO_2 , H_2S and water vapours and salts like nitrates, sulphates, phosphates and potassium ions. These are reused by green plants during photosynthesis and other synthetic processes.

Nitrogen Fixation

Another important function performed by bacteria is nitrogen fixation. Nitrogen fixation is the conversion of molecular nitrogen (N_2) of atmosphere to soil nitrogen in the form of nitrites and nitrates, thus increasing soil fertility.

Nitrogen is an important component of Protein

Nitrogen Fixation By Bacteria

Free-living Nitrogen Fixers

Bacteria of this type called nitrifying bacteria use carbohydrates from the soil, humus and atmospheric N_2 to make nitrates. These nitrates are used by plants.

Symbiotic Nitrogen Fixers

Bacteria of this type live inside the roots of leguminous plants (e.g. peas, beans) where they form tiny swellings called **root nodules.** Bacteria obtain both protection and carbohydrate from plant cells and in return release nitrates into the plant tissues and the soil. An association of this kind in which both organisms get benefit by living together is a type of symbiosis and is called mutualism. (Fig 20.3)

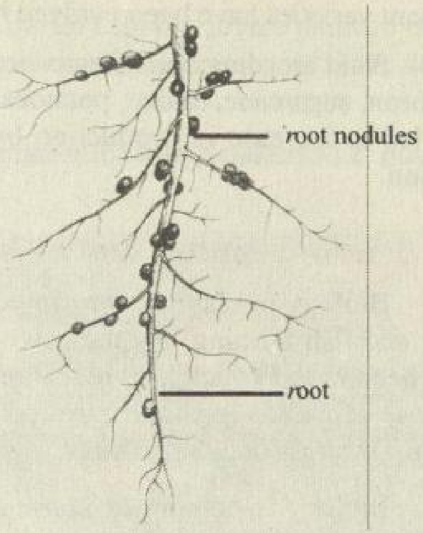


Fig. 20. 3 Root nodules on a bean plant

20.3 Application of Biology

The knowledge of Biology is playing very important role in the welfare of human beings. Advance studies in biology specially genetic engineering, plant and animal breeding and biotechnology have influenced man's economic, social and industrial progress. They have enabled man to develop high yielding crops, better strains of livestock and many other developments beneficial to man. They are proving helpful in meeting the demands of rapidly growing population. Some of the contributions of biology in the economic development of various aspects of human life are given below: -

20.3.1 Forestry, Fuel, Furniture

Forestry is the business of cultivating trees which provide us fuel, timber and wood products. Timber is used for making furniture. Paper industry is also dependent upon wood. Turpentine and resins are extracted from many of the trees.

Advancement in biology has helped forest cultivators in choosing trees that fit successfully in local habitat. Modern plant breeding techniques have developed various varieties of plants that can tolerate wide range of climatic conditions and are fast growing, in addition to being of high productivity, palatability and nutritional content. So forest cultivators select varieties which satisfy all their requirements.

20.3.2 Agriculture

A breed is a collection of individuals within a species which are evolved by selective mating for some definite set of qualities.

Food and clothing are basic necessities of mankind. With the increase of population man thought of securing more food by cultivating the most desirable plants and domesticating animal breeds. Application of the biological knowledge has enabled scientists to increase yield of crops and to improve quality of fruits and vegetables. In agriculture, cereal crops like wheat, corn, rice have been selectively cultivated and crossed with other varieties to produce super strains capable of giving a palatable high yielding crop in a minimal amount of time. Disease and pest resistant varieties have been evolved by plant breeders.

Plant breeding and selective cultivation has also enabled agriculturists to improve the yield of soyabean, sugarcane, maize, potatoes and almost all other crops and fruits. Biological knowledge has also led to increase in production by the use of fertilizers, better methods of cultivation and crop rotation.

20.3.3 Dairy, Poultry and Fish Farming

Biology is playing very important role in the economic development, in the field of poultry, dairy and fish farming. By the use of animal breeding technology, cross breeds of different animals have been raised which provide better protein source in the form of meat and high milk production in the case of cattle, eggs and meat production in the case of poultry and wool & meat in the case of sheep. The cross breeds are more resistant to disease and are more vigorous (Fig 20.4).

Biology is helping to know more about diseases and their cure by studying various disease causing agents like viruses, bacteria and other parasites.

Biological knowledge helps in the development of balanced diet for different animals which is necessary for their rapid and speedy growth. Ideal feed is that which has better food conversion ratio.

Fig 20.4 A prize bull- the result of improved cross-breeding

20.3.4 Sericulture

Sericulture is the production of silk by the activity of worms known as silk worms. This process of rearing silk worms had been crude and laborious and often various diseases of silk worm wipe out all cocoons. Biological knowledge has enabled the farmers to overcome these and many other problems associated with Sericulture.

Adult silk moth female lays eggs, which hatch in three to four days. Young larvae feed on buds and new shoots of mulberry. Thy grow in size and when fully-grown, silk worm larvae stop feeding and spin a continuous silk thread around it forming a cocoon. After few days cocoons are placed in hot water to kill the Pupa. Workers then pick up one end of the thread and pass it over a reeling machine. These strands are then passed on machine to produce the fabric. Biologist have helped, making revolutionary progress in this field.

> Japanese biologists have developed a wingless variety of silk moth which is easy to handle.
> Some varieties which complete 5-6 life cycles in a year have been raised.

20.3.5 Apiculture

Domesticating the honeybee for the honey production is known as apiculture. Honeybee is a social insect and lives in large colonies. Honeybees are trimorphic, consisting of queen, drones and workers. The queen bee is larger than the rest and is protected and fed by the workers. It is meant for egg laying. Workers collect nectar and pollen making honey, secrete wax, protect and feed the queen. Drones are male and their function is to fertilize the eggs and they no role in honey formation.

Biological knowledge has led to a better understanding of usefulness of honeybees. Some varieties of domestic honeybees have been imported and their new breeds have been raised by the biologist in Pakistan.

20.3.6 Pests and their biological control

A large number of organisms damage useful plants and animals causing severe damage to our economy and even to livestock and public health. Such destructive organisms (insects etc.) are called **Pests**. There are many methods to control the pests: e.g.

- **Primary or cultural control:** Crop rotation should be used instead of mono cultures i.e. planting of only single-species crops again and again.
- **Chemical control:** Chemicals like DDT are used as insecticide. Insects have developed DDT resistant strains. These insecticides also increase the toxicity and pollution, thus their use is now being discouraged.
- **Biological control:** Biological control is the most promising pest control method. The method utilizes natural enemies like predators, parasites and pathogens of pests to control and destroy the pests (Fig 20.5).

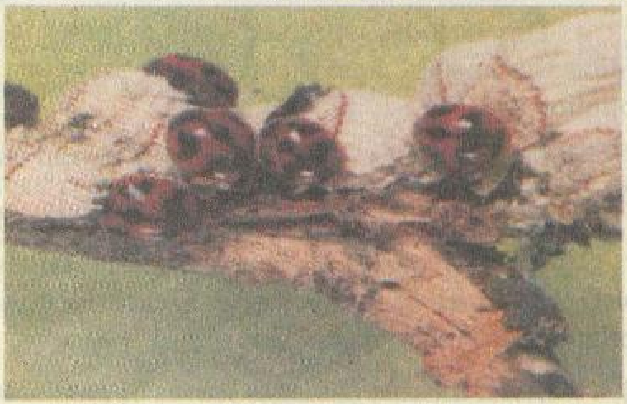


Fig. 20.5 Biological control of pests - here lady bugs are being used to control cottony cushion scale insect on citrus tree

Advantages of Biological Control Method

- They do not pollute the environment
- They do not disrupt and disturb the natural ecosystem.
- They usually provide permanent control of pest population, because pests rarely develop resistance to natural control.

Currently in some developed countries Lace wings and Lady beetles (predatory insects that feed on a variety of other pest insects) are raised commercially. Lace wings are much effective for controlling ball worm population in cotton fields. Recently certain pest pathogenic viruses have also been proved effective in controlling cotton ball worm and corn ear worm.

Pest pathogenic bacteria are also of great importance in this respect. Spores and toxins of the bacterium *Bacillus thuringiensis* are sprayed on leaves, vegetables and flowers. They infect and kill the larvae of at least twenty species of butterflies and moths.

20.4 Pollution

Contamination of the environment with waste products and other impurities is called **Pollution**. And the substances whose presence in air, water or soil is harmful to human beings, animals, plants and soil are termed as **pollutants** (Fig 20.6).

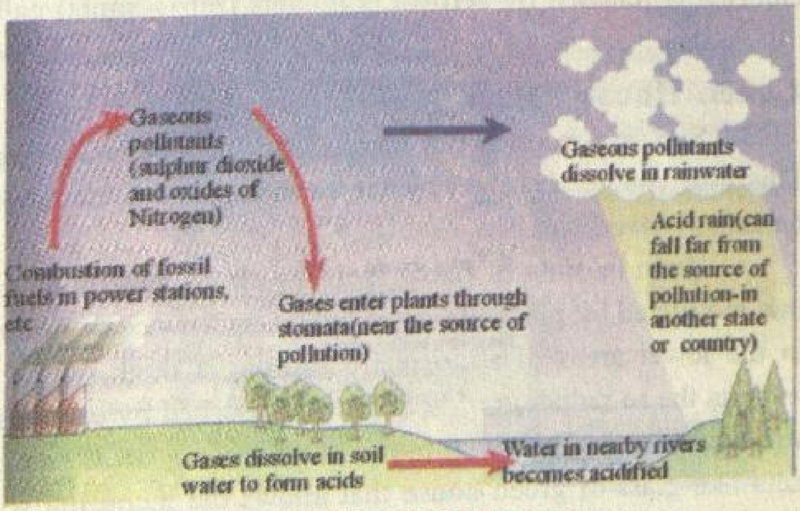

Gaseous pollutants (sulphur dioxide and oxides of Nitrogen)
Gaseous pollutants dissolve in rainwater
Acid rain(can fall far from the source of pollution-in another state or country)
Combustion of fossil fuels in power stations, etc
Gases enter plants through stomata(near the source of pollution)
Gases dissolve in soil water to form acids
Water in nearby rivers becomes acidified

Fig. 20.6 Air Pollution

20.4.1 Types of Pollution

Pollution may be classified as

- Air pollution
- Water & soil pollution
- Sea pollution
- Radiation
- Noise

Air Pollution

Air pollution is mainly caused by dust, sulfur dioxide, carbon dioxide, carbon monoxide, nitrogen oxides, hydrocarbons and ozone. Common sources of air pollution are;

1. Fuel gases from garbage burning.
2. Exhaust gases from fossil fuels burning in industries and auto motives.

Water and Soil Pollution

This includes untreated sewage, pesticides and fertilizers, inorganic compounds, waste from radioactive metals, heavy metals like mercury, cadmium, arsenic etc. Sources of water and soil pollution are;

1. Municipal wastes
2. Industrial wastes
3. Agricultural wastes

20.4.2 Effects of Pollution on Environment

The environment is being severely damaged by the pollution and is becoming hostile or unfit for the survival of many forms of life including mankind. Following are some of the effects of pollution on environment.

(i) Sulfur dioxide damages leaves of plants. It corrodes metallic and stone structures.

(ii) Higher concentrations of carbon dioxide are harmful to animals.

(iii) Carbon monoxide combines with hemoglobin to reduce oxygen in blood.

(iv) Oxides of nitrogen corrode metals and stones. They produce photochemical smog that inhibits the plants growth.

(v) Higher concentrations of ozone reduce air visibility and cause health problems e.g. eyes irritation and headache.

(vi) Untreated sewage is a source of germs causing cholera and typhoid etc.

(vii) Densely populated bacteria in water due to pollution consume the oxygen of water, effecting the water animals and even death of fishes.

Ozone Depletion

Oxygen in the upper atmosphere forms ozone that forms a layer over the earth. This ozone shield filters out the ultraviolet rays of the sun and protects the earth from being damaged.

Ozone shield may be in danger of breaking due to air pollutants particularly nitric oxide and chlorine atoms that attack the ozone layer. Nitric oxides come from emission of aircrafts exhaust and chlorine is released by aerosol pollutants (refrigerants) called chlorofluorocarbons (CFC).

Green House Effect

Sun rays reach to our earth in the form of visible light and raise the temperature of the earth. This heat energy absorbed by the earth radiates back to space thus temperature of earth remains in balance.

From burning of fossil fuels, much carbon dioxide is produced in atmosphere. About half of this is utilized by plant life or absorbed by the ocean water and the remaining goes on accumulating in the lower areas of atmosphere forming a thick dense layer of carbon dioxide. This thick layer inhibits the re-radiation of heat energy absorbed by earth back to space and adds more temperature to surface of earth. This warming of earth surface is called **Green House Effect**. The thick layer of gas acts like glass of green house that allows the incoming solar radiation but prevents the emission of the outgoing heat waves.

Biological Oxygen Demands (BOD)

It is a measure of water pollution level due to sewage and other organic matter. Biological oxygen demands (BOD) is the amount of oxygen needed by microbs to decompose the organic matters of water in a fixed period of time, normally 5 days. So large amount of sewage waste in water creates a high BOD, which robs the water of dissolved oxygen.

Acid Rain

Sulfur dioxide and oxides of nitrogen react with oxygen and rain water readily to form sulfuric acid & nitric acid respectively . Rain containing these acids is known as **acid rain.**

Large amounts of acid rain may cause death of fish in lakes and rivers. Acid rain dissolves aluminum salts in the soil and washes them into lakes and rivers. High concentrations of these salts is poisonous to fishes.

20.4.3 How to Control Pollution?

Some of the important measures to be taken for pollution control are;

(i) *Use of lead free and low sulfur fuel oils.*
(ii) *Appreciated use of environmental friendly products e.g. natural gas and liquefied petroleum gas in place of high speed diesel and furnace oil.*
(iii) *Use of wet scrubbers in chimneys of power plants to remove sulfur dioxide.*
(iv) *Adequate maintenance of auto vehicles for proper ignition.*
(v) *Installation of heavy process industry far from populated areas.*
(vi) *Minimum use of non-biodegradable products.*
(vii) *Use of narrow spectrum biocides.*
(viii) *Installation of sewage treatment plants.*
(ix) *Maximum possible arrangements for recycling of wastes.*
(x) *Use of incinerators to handle municipal and hospital solid wastes.*
(xi) *Maximum forestation.*

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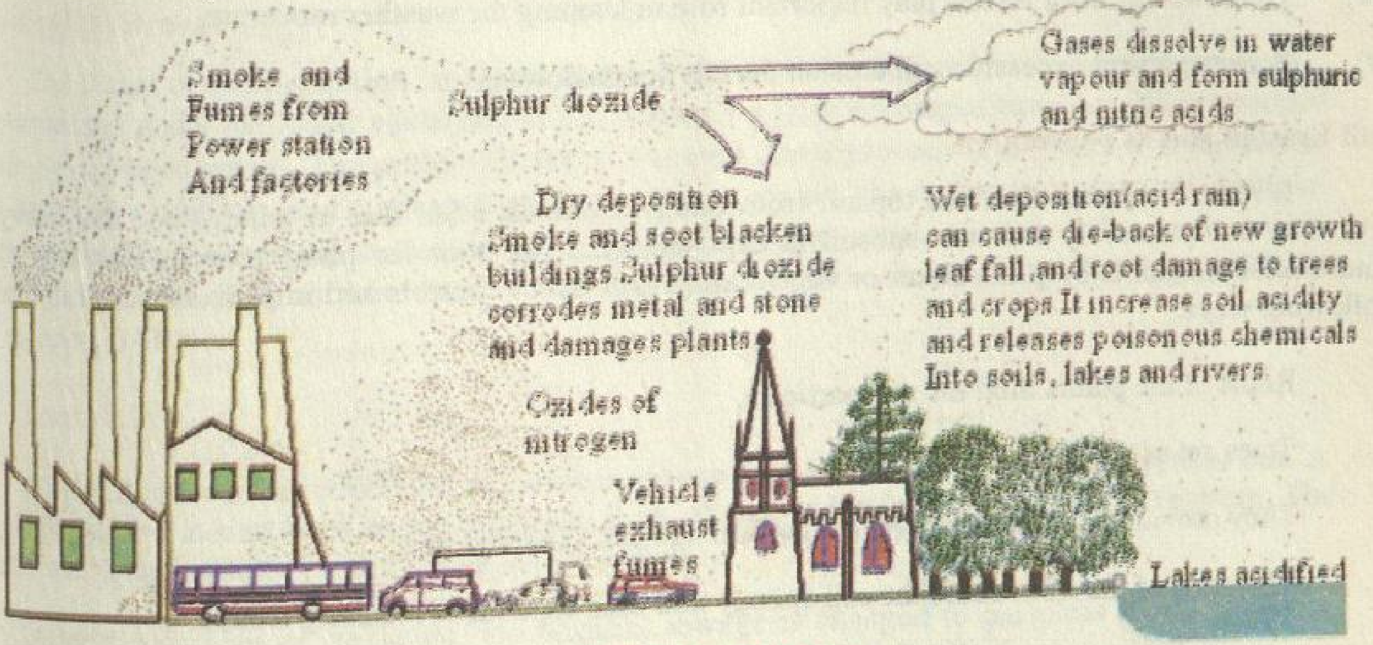
Smoke and Fumes from Power station And factories
Sulphur dioxide
Gases dissolve in water vapour and form sulphuric and nitric acids
Dry deposition Smoke and soot blacken buildings Sulphur dioxide corrodes metal and stone and damages plants
Wet deposition(acid rain) can cause die-back of new growth leaf fall ,and root damage to trees and crops It increase soil acidity and releases poisonous chemicals Into soils, lakes and rivers
Oxides of nitrogen
Vehicle exhaust fumes
Lakes acidified

Fig. 20.7 Acid Rain

20.5 Conservation

It is necessary to protect and preserve the natural resources to maintain a stable and balanced ecosystem for the benefit of mankind. Natural resources may be renewable or non-renewable resources.

Renewable Natural Resources: These are the resources which are never depleted and natural cycles constantly replace these materials. For example air, water, forests, soil, wildlife.

Non-Renewable Natural Resources: The resources that are depleted or destroyed and cannot be reused. For example fossil fuels, minerals etc.

How to Conserve?

Natural resources can be conserved either

(i) **Directly** by taking care of natural resources.

(ii) **Indirectly** by controlling human population and consequently reducing pollution level.

Conserving Forests

Trees enrich the beauty of the nature. They are nature's lungs because they consume the atmospheric carbon dioxide and produce oxygen which is released into atmosphere during the daytime. The animals consume oxygen and deplete the atmosphere of the oxygen, where as trees replete the atmospheric oxygen. Forests save mankind in many ways e.g.

(i) Trees provide shade to human beings, animals and soil.

(ii) Living of many animals depends on the forests.

(iii) Forest cover reduce rate of evaporation from soil.

(iv) Transpiration from forests play important role in keeping the weather moderate.

(v) Forests prevent excessive soil erosion during floods & rains

Soil Erosion and its prevention

It refers to removal of the topsoil from one place to an other due to wind, flood and heavy rain. The comparatively infertile subsoil is exposed which is poor for plant growth. Best way to control soil erosion is by plant cover or vegetation. Plant cover controls and improves the soil in the following ways.

1. Roots of the plants bind the soil particles.
2. Trees act as windbreakers.
3. They provide a protective cover for the soil against wind and rain.
4. The roots of the trees make the soil spongy and thus capable of retaining water.

Recycling

Recycling is the reprocessing of wastes into a state from which new useful items can be produced. Many substances of common use e.g. steel, paper, glass, plastics and rubbers can be recycled. A good way of pollution control is by reducing the solid waste. Recycling of sewage water and car wash stations may save water wastage. Recycling saves energy and money overall.

20.6 Treatment of Organic Sewage

Sewage consists of faeces and urine alongwith water from kitchens, washrooms and shops. It may contain industrial waste too. Sewage contains germs and eggs of parasitic worms so it is necessary to dispose it in such a way that the parasites may not contaminete ground drinking water. Moreover the disease vectors like flies, rats and cockroaches can be infected by these pathogens and can spread the diseases to healthy persons. Treatment of municipal sewage involves the following steps.

1. Screening

Large objects such paper, sticks, rags and discarded fruits are removed by passing through series of screens.

2. Settling in Grit Tanks

The velocity of screened sewage is reduced by passing it through grits. Particles like sand, silt and small stones settle down.

3. Sedimentation

The water is made to remain still for long times. Suspensions and lighter solids settle down as sludge which is taken for dewatering in a separate unit. Where as liquid from tank overflows which is further treated.

4. Biological Processing

The liquor of sedimentation tank containing materials is biologically treated. oxygen of air , microorganisms and a particular environment are needed for such decomposition. All this is arranged in a single equipped vessel. The polluted water is pumped into a process tank where it is mixed for hours and hours with **air and activated sludge.** A fast moving chain sets in operation. Bacteria respire aerobically consuming molecules of proteins ,fats and carbohydrates . The protozoa as secondary consumers feed on these bacteria. This decomposition is accelerated by adding fertilizers such as **urea, DAP** etc.

5. Sedimentation

The treated water is introduced to a sedimentation tank where activated **sludge** settles out. A part of this sludge is sent back to process tank. Rest of the sludge is taken out for dewatering. The treated water is sometimes disinfected by chlorine gas.

After these stages of treatment, the original sewage is changed to harmless liquid which is drained into rivers and seas. The solid sludge obtained may be used as fertilizer.

20.7 Population

Human population means the number of people living in a particular area. The area may be town , a district, a country or world as a whole. The human population grows when more people are born each year than die. The rapid rate of human population is a matter of great concern for the ecologists.

Ever increasing human population is continually using and depleting the natural resources on the earth and upsetting the balance of nature. This rapid growth of population has led to an increase in demand for land. To fulfill this demand forests are cleared and trees are cut down. This is known as **deforestation**. Whenever the land of any region is cleared for any purpose, the natural ecosystem of that region is destroyed which in return results in the destruction of natural habitats and disturbance of the balance of nature.

Purposes of Deforestation

- Urban development: Land is cleared for building, houses, roads, factories etc.
- Cultivation: For growing crops.
- Grazing: Large open grassland have to be provided for grazing by cattle, sheep etc.
- Timbers: Wood is needed for construction, furniture making, paper

20.8 Organisms Affecting Human Health

Microorganism

Very minute living organism not seen without the aid of microscope are called microorganisms. There are numerous microorganism but ones which concern us are germs or disease causing microorganisms (called pathogens). They are found almost everywhere in nature (in air, water and soil), on the surface of objects and living organisms, within the living organisms.

Pathogenic microorganisms are viruses, many bacteria, certain fungi and some protozoan.

Viruses

Viruses cause disease in living cells and are the smallest disease causing particles known. They are only visible under electron microscope. Chickenpox, measles, poliomyelitis, the common cold, mumps, influenza and AIDS are a few diseases caused by viruses.

Bacteria

Bacteria are larger than viruses and are visible under the ordinary light microscope. All of the bacteria are not pathogens.

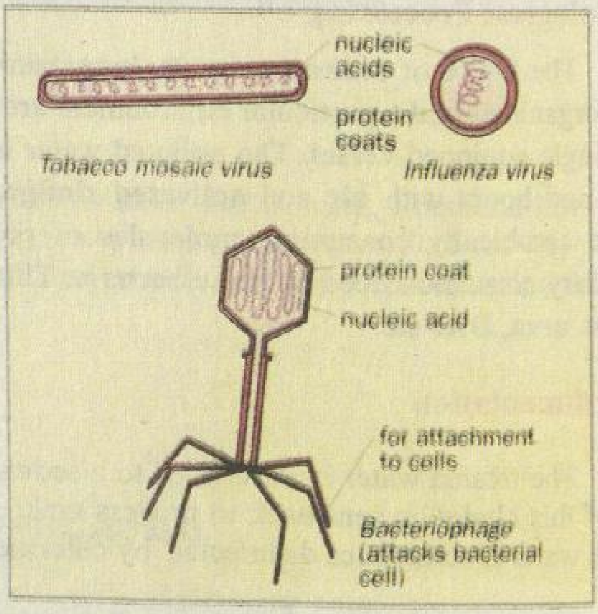

Fig 20.8 Structure of Virus

Some of the diseases caused by bacteria include boils, food poisoning, whooping coughs, cholera, diphtheria, typhoid, bacillary dysentery, TB etc.

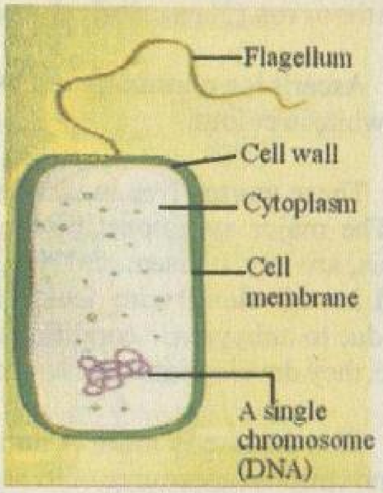

Fig 20.9 Structure of Bacterium

Protozoa

Protozoa are single-celled organisms which vary in size and shape. Very few of them cause disease in humans. Some common diseases caused by protozoa are malaria, amoebic dysentery, some types of ulcers in large intestine, etc.

Fungi

Very few fungi are responsible for causing human diseases. Most of the fungi are multi-cellular but some are unicellular. Their mode of nutrition is saprotrophic but very few of them are human parasites. Common fungal human diseases are Ring Worm, Athlete's foot, histoplasmosis, candidia (thrash) etc.

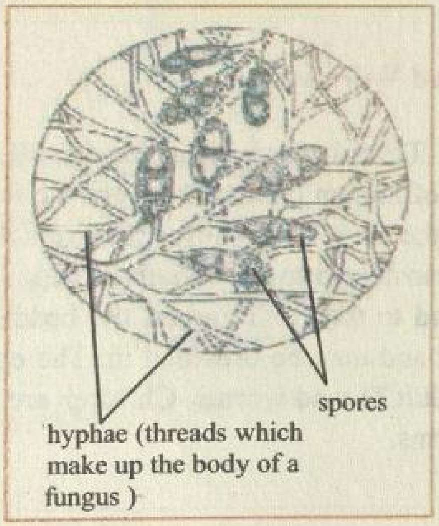

Fig. 20.10 Fungus which causes Ring

Ring Worm

Ring Worm is a skin disease caused by fungus. The disease is spread by spores of the fungus which are passed from one individual to another by personal contact or by contact with clothing since the fungus can grow on clothing or other personal objects. Hyphae of the fungus penetrate the outer layers of the skin and grow in the normal way. The red patch as it spreads, causes intense itching. As the fungus grows, the center loses its colour to normal leaving a circular red patch which is darker at the edge. The name 'ring worm' is given because of this appearance.

Athlete's Foot

Athlete's foot is also a fungal disease. It is sort of ringworm of the foot. Fungus attacks soft skin between the toes and in bad cases spreads over the whole foot. The skin peels off leaving very sore patches.

Infected floors and mats spread the problem.

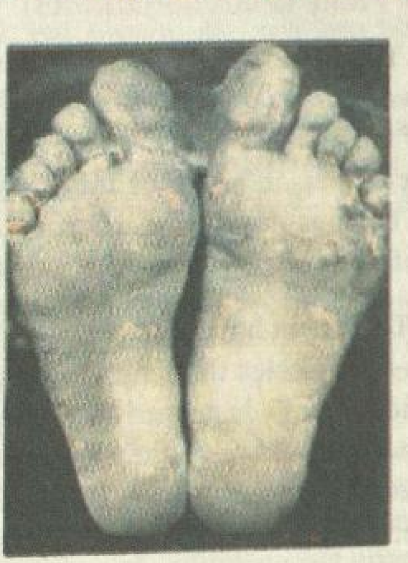

Fig. 20.11 Athlete's Foot

20.9 Some common Parasitic Worms

Some common parasitic worms are round worms, thread worms, liver fluke and tapeworms.

Roundworms (Nematodes)

Ascaris is a common roundworm. It is 20-30 cm long and is pinkish white in colour.

These worms live in the small intestine of man and move freely. The major symptoms of the disease are abdominal pain, dyspepsia, anxiety, nausea, and coughing. The eggs of Ascaris are excreted in soil along with feces. These eggs can enter another person, due to unhygienic conditions. When these eggs reach small intestine, they develop into new worms and cause disease.

This disease is more common in children as compared to adults and children are source of its spread.

In this disease, as the worms feed on the food of the patient, that is why patient suffers from malnutrition.

Thread Worms

Thread worms are very small only ½ inch long. Both male and female worms live in the colon of human beings. At night the female descends the colon and lays her eggs in the folds of skin about the anus. This causes intense itching, if the anus is scratched, the eggs stick to the fingers and thus transferred to the mouth or deposited on cutlery and household utensils. The eggs also become attached to the clothing and the bedding. When these articles are shaken, the eggs are dispersed in the air and may be breathed in. The eggs pass to the stomach and to the large intestine and develop into adult Thread worms. Children are mainly affected by these worms. Drugs can be given to get rid of worms.

Liver Fluke (Platyhelminthes)

The fluke are flat worms. They are the parasites of both man and animal. All flukes require at least two hosts to complete their life cycle. One of the fluke is liver fluke. It lives in and feeds in the liver of the human beings, where it causes much damage. The eggs of the fluke pass out in the faeces of infected person and thus they may come to the freshwater. Snails living in the freshwater eat the eggs. The eggs develop and form larva in the snails. The larva develops into small creature with a tail. At this stage they leave the snail and swim into water and seek a fresh host.

Their next host is freshwater fish. The embryos penetrate the skin and enter the muscles of the fish. In the muscles the embryo form a hard protective layer and become cysts. These cysts are very hard and are only destroyed by a thorough cooking of the fish. When partially cooked fish is eaten by man, the cysts arrive in the stomach and there they develop. From the stomach the parasites pass to the liver, where they grow to adult flukes. The adult flukes are both male and female, they come together and fertile eggs are produced and the cycle is repeated (Fig 20.13).

Drugs for the treatment are available but the best way is to improve sanitation.

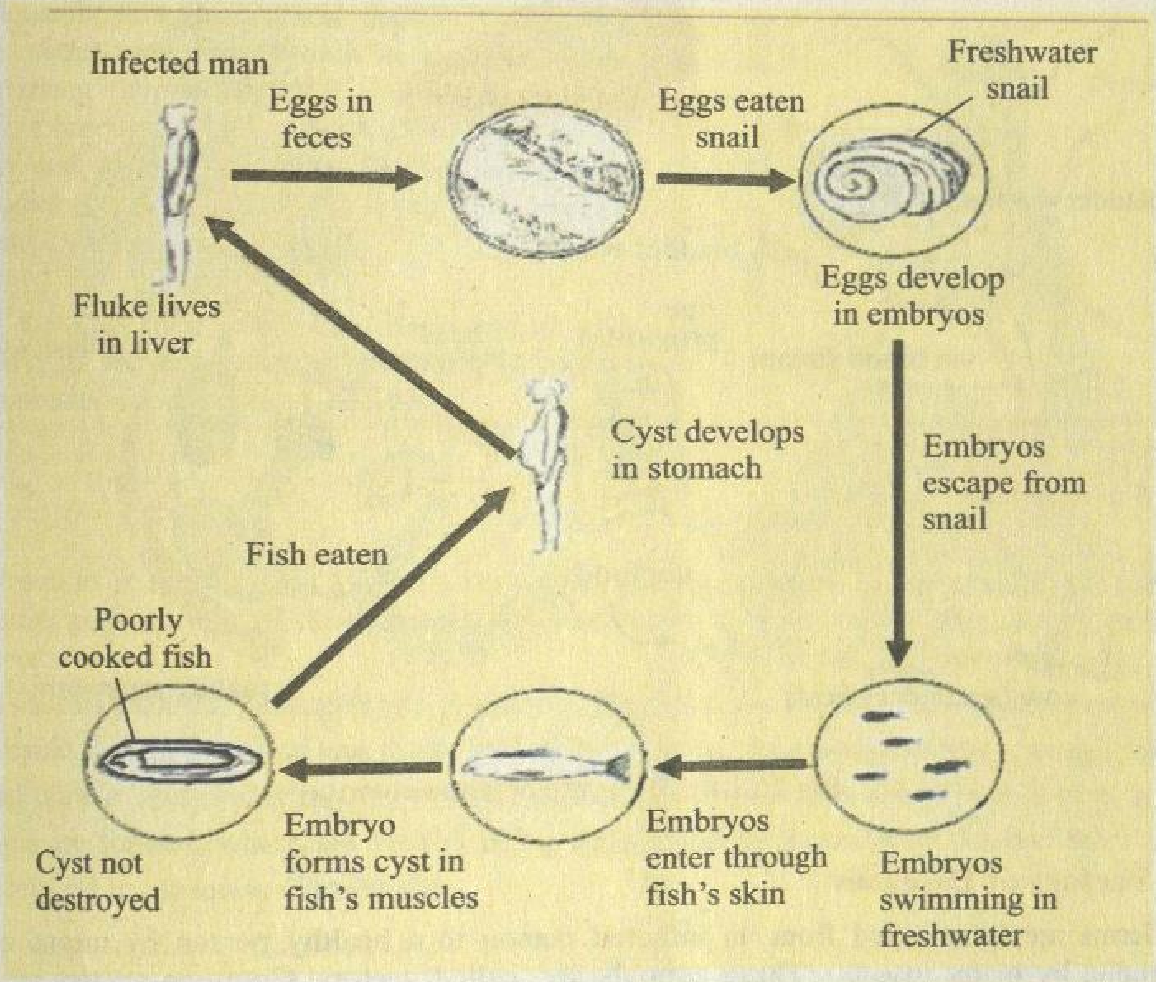
Infected man
Eggs in feces
Eggs eaten snail
Freshwater snail
Eggs develop in embryos
Fluke lives in liver
Cyst develops in stomach
Embryos escape from snail
Fish eaten
Poorly cooked fish
Cyst not destroyed
Embryo forms cyst in fish's muscles
Embryos enter through fish's skin
Embryos swimming in freshwater

Fig. 20.13 Life cycle of Liver Fluke

Tapeworms (*Taenia solium*)

Flat worms are largest organisms to parasitize human beings. They are called flat worms because of their flattened bodies. All tapeworms are parasites and require at least two hosts to complete their life cycle.

Tapeworms have a small head on which suckers and sometimes hooks are present to attach them to their host's intestine. Their length varies from few centimeters to 10 meters and their body is made of segments called **proglottids**. They are hermaphrodite i.e. each proglottid has both sexes.

The life cycle of tapeworm involves two hosts. Primary host is the one in which the adult tapeworm lives and reproduces. And secondary host is an animal, which is eaten by the primary host For example beef tape worm's primary host are humans and secondary host is cattle. If the sewage disposal conditions are not proper, tape worm eggs may be eaten by a cow while grazing. Because of the digestive juice of cow in the gut, larvae come out of the eggs which then find their way into the muscular tissues. There they remain unchanged for several years. If the partially cooked cow meat of infested cow is eaten by humans the larvae are activated by digestive juices, where they manage to attach the intestinal wall with their suckers or hooks. There the larvae develop into adult tapeworms. After fertilization sex organs disappear and are replaced by thousands of microscopic proglottids. At this stage proglottids drop from the tape worm and pass out of the host's body with faeces (Fig 20.14).

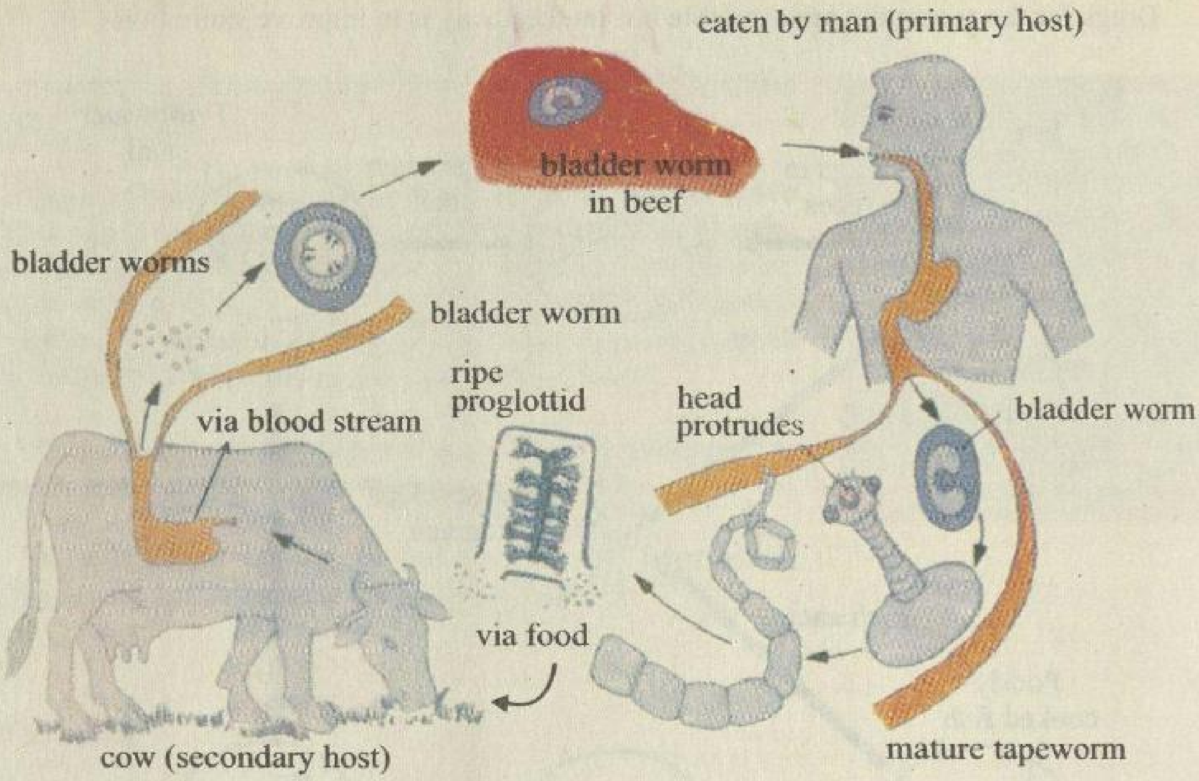
eaten by man (primary host)
bladder worm in beef
bladder worms
bladder worm
ripe proglottid
via blood stream
head protrudes
bladder worm
via food
cow (secondary host)
mature tapeworm

Fig 20.14 Life cycle of Tapeworm

20.8.1 Vectors of Diseases

Germs are transmitted from an infected person to a healthy person by means of animals (for example; by many insects). These animals are called vectors. Common vectors are housefly, sand fly, mosquitoes, fleas, cockroaches, dogs, mice etc. (Fig 20.15)

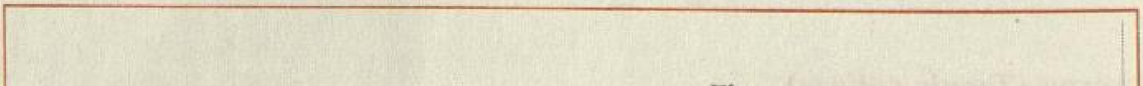
Flea
(transmits plague, typhus, certain tapeworms' eggs)
Droplets of moisture from infected people
Contaminated food and water
Contact with contaminated objects (e.g. coins, books, door knobs, toilet fittings)
Mosquito
(transmits malaria yellow fever, dengue fever and other diseases)

Fig. 20.15 Diagram summarizing the spread of infections

Housefly as a Vector of disease

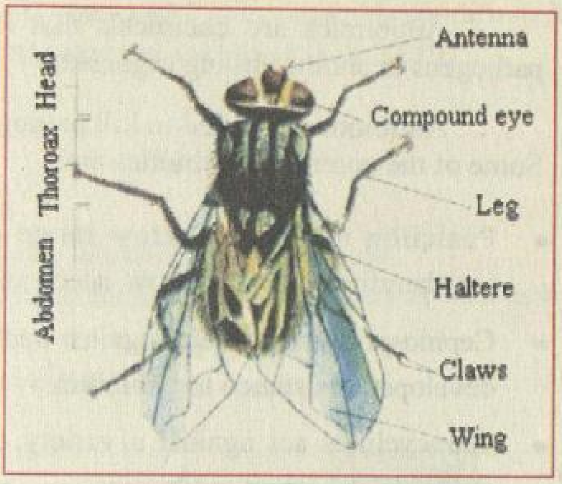
Head
Thorax
Abdomen
Antenna
Compound eye
Leg
Haltere
Claws
Wing

Fig. 20.16 Housefly

Housefly is a mechanical vector. It feeds on decaying matter and dung which is rich source of germs causing typhoid fever, typhus, cholera, dysentery, tuberculosis and anthrax along with some tapeworm and roundworm eggs. As flies feed their feet, bodies and digestive system becomes contaminated with germs and eggs.

If the flies then settle on human food, the germs and eggs are deposited on the food. By eating this contaminated food persons become ill.

Mosquitoes as Vectors

Mosquito is a biological vector because the pathogen which is responsible for causing the disease under goes a cycle of development in it. Mosquito is a vector for transmitting malaria and yellow fever.

In case of malaria, pathogen is a protozoan *Plasmodium*. *Plasmodium* under goes two stages in its life cycle, one in man and one in the mosquito. In man, the parasite enters through the bite of an infected female *Anopheles* mosquito. One stage of its life cycle is completed in man, as a result gametocytes are formed, which are sucked along with blood by a mosquito. Second stage of its life cycle is complete in mosquito (Fig 20.17).

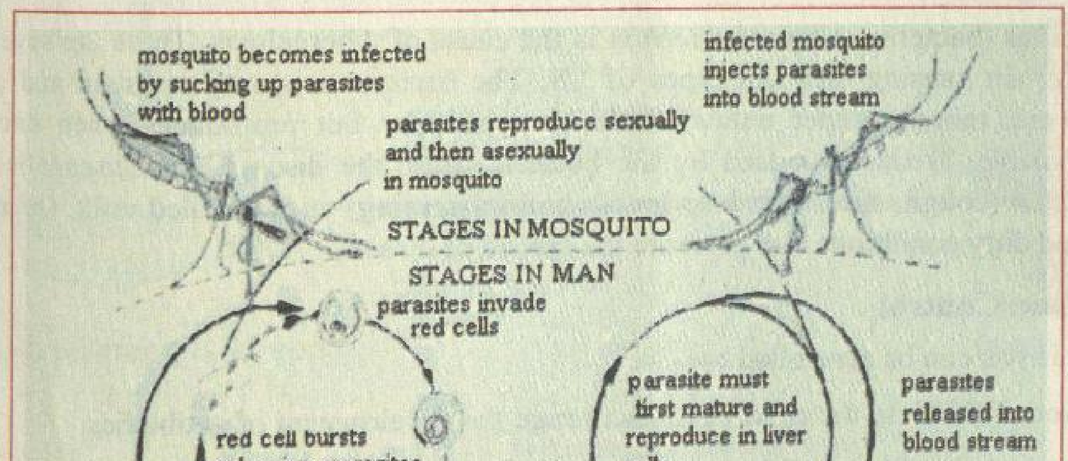
mosquito becomes infected by sucking up parasites with blood
infected mosquito injects parasites into blood stream
parasites reproduce sexually and then asexually in mosquito
STAGES IN MOSQUITO
STAGES IN MAN
parasites invade red cells
parasite must first mature and reproduce in liver cells
parasites released into blood stream
red cell bursts releasing merozites and toxins
cycle repeated
parasites reproduce in red cells

Fig. 20.17 Life cycle of *Plasmodium*

The mosquito in its life cycle is an intermediary host. Without this intermediary stage, the disease would not be passed from patient to healthy person.

ANTIBIOTICS AND THEIR IMPORTANCE

Antibiotics are chemicals that are extracted from one living organism and which destroy pathogens in another living organism.

Antibiotics are used to kill pathogenic bacteria but they do not harm viruses.
Some of the common antibiotics are;

- Penicillin attacks a narrow range of bacteria and are therefore called narrow spectrum antibiotics.
- Cephlosporins are useful against bacteria which have developed resistance to penicillin.
- Tetracyclines act against a variety of bacteria. They are broad spectrum antibiotics.
- Erythromycins are useful against bacteria which have developed resistance to penicillin.

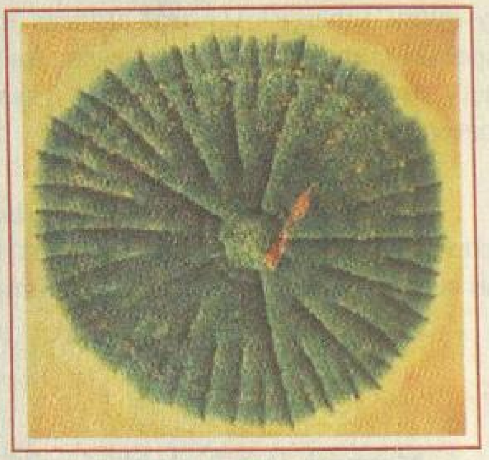

Fig.20.18 Penicillium chrysogenum

20.9 Some Common Diseases

Tuberculosis (TB)

Tuberculosis is worldwide but is most common in tropical areas. Tuberculosis takes a long time to develop but depends mainly upon the health and state of the people. Most common TB. is of the lungs, apart from TB of intestine, bones etc.

Causative Organisms

A bacillus (bacterium) *Mycobacterium* is the cause of tuberculosis. There are several species of *Mycobacterium* causing different types of TB. The bacterium is very resistant and can remain alive for several months under unfavourable circumstances but reproduces when circumstances become favourable. Toxins produced by the bacteria cause the disease. The disease is spread by droplet infection (cough, sneezing, deep breath and by spitting) and unboiled milk. Over-crowding and humid and dirty conditions also promote the spread of disease.

Treatment and Control

The disease can be controlled by;

- Vaccination of BCG to the children to encourage the development of antibodies.
- Revaccination after three to five years.
- Use of thoroughly boiled or pasteurized milk.
- By keeping patients in isolated places or separate rooms in the houses.

Disease can be cured in its early stages. During treatment more milk and meat should be taken and the patient should be given rest for months.

Cholera

Cholera is mainly found in Asia and commonly spreads in humid conditions. Disease begins with fever, diarrhoea and vomiting, accompanied by severe abdominal pain. Severe attacks result in dehydration and death of the patient.

Causative Organism

Cholera is caused by a comma-shaped bacterium called ***Vibro cholera*** with a flagellum which enables it to swim in water. *Vibro Cholera* is ono-caplulated and cannot withstand dry condition. It is water born. The disease is spread by the use of contaminated water and food (Fig 20.19).

Control over the Disease

- By the use of boiled or chlorinated water.
- By keeping our food covered to avoid its contamination.
- By injecting cholera vaccine which gives an active artificial immunity for six month.
- By keeping infected persons in isolated places as the bacteria are transmitted by flies as well as by water.
- Good sanitation is required to prevent the contamination of water.

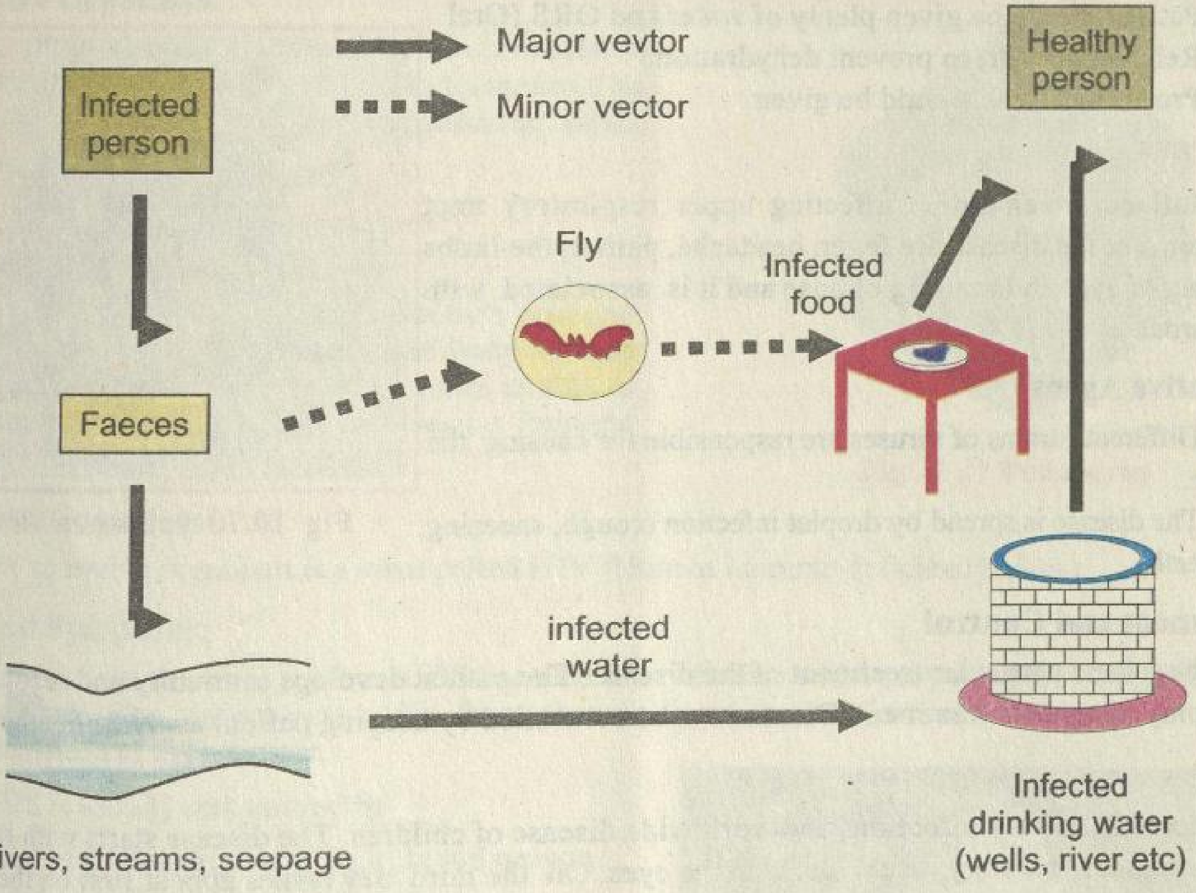
Major vevtor
Minor vector
Infected person
Healthy person
Fly
Infected food
Faeces
infected water
Rivers, streams, seepage
Infected drinking water (wells, river etc)

Fig 20.19 Disease cycle of cholera

Treatment

Saline solution is continuously injected into vein of patient to maintain the body fluid balance. This does not kill the bacteria but enables the patient to overcome the effects of dehydration and allow his own body to fight the disease. Drugs (antibiotics) are also given to kill the bacteria.

Bacillary Dysentery

Bacillary dysentery is a food-born disease. Symptom of the disease is severe pain in the lower abdomen. It is followed by diarrhoea and fever. There is appearance of mucous and blood (in the case of severe attack) in the stools.

Causative Organism

Bacillary dysentery is caused by rod-shaped (bacilli) bacteria. The bacteria are motile and are found in the faeces of patients in large numbers. The disease is spread by the use of contaminated food and from unwashed hands after using lavatory.

Control over Disease

- By protecting cooked and uncooked food from houseflies.
- By careful washing of hands after using toilet.
- By adopting proper methods of sanitation to prevent flies from sitting on human faeces and breed there.

Treatment

- The patient should take rest and eat no solid food for a day or two.
- Patient should be given plenty of water and ORS (Oral Rehyderate Salt) to prevent dehydration.
- Proper medicine should be given.

Influenza

Influenza is an illness affecting upper respiratory tract Symptoms of the disease are fever, headache, pain in the limbs, watering of eyes and running of nose and it is associated with sore throat.

Causative Agent

Different strains of viruses are responsible for causing the disease.

The disease is spread by droplet infection (cough, sneezing, and breath).

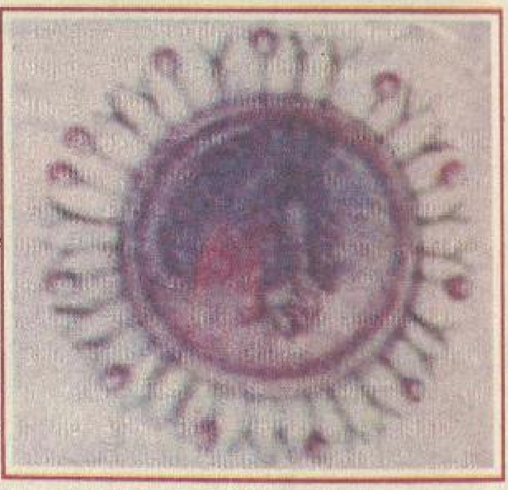

Fig 20.20 Influenza Virus

Treatment and Control

There is no particular treatment of the disease. The patient develops immunity and recovers. Rest is the only immediate treatment. Disease can be controlled by keeping patient away from other people.

Measles

Measles is a very infectious and worldwide disease of children. The disease starts with fever with cold, cough and a watery discharge from the eyes. On the third day rashes appear first on the face and then spread over the whole body.

Causative Organism

The causative organism is a virus, which is air born and is inhaled in droplets. The disease spreads through the discharge from eyes and nose, which becomes air-born and spreads rapidly.

Treatment and Control

There is no specific treatment. Child develops immunity and the signs and symptoms of the disease disappear after seven days. The child should be given plenty of drink especially milk.

It is difficult to control the disease because it is highly infectious as the patient becomes infectious about 2 days before the symptom of the disease develop.

Poliomyelitis

Poliomyelitis is most common among the children but young and old people can also become its victims.

It begins slowly. The sufferer has very high fever, headache, nausea, fits and stiffness of limbs. In severe cases, the virus attacks the nerve fibers of the spinal cord causing paralysis of the limbs and muscles of the respiratory tract, sometime proving fatal, apart from permanent disabilities.

Treatment and Control

There are two polio vaccines; sabin vaccine and salk vaccine. Sabin vaccine is more common and is given orally in the form of drops. Two or three drops are given to infants during their first year which provides life long protection against polio by developing active immunity against it. Salk vaccine is injected in to the body but it is not being practiced in our country.

Causative Organism

Poliomyelitis is caused by virus, which is transmitted by infected water. It is also transmitted by droplet infection during coughing and sneezing, of the patient.

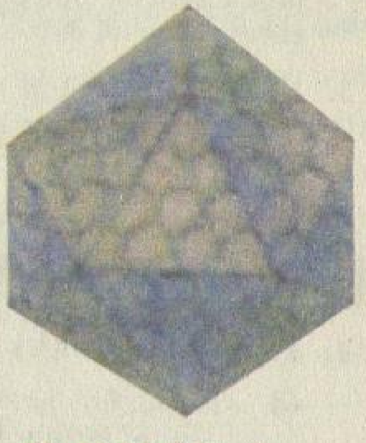

Fig 20.21 Polio virus

AIDS (Acquired Immune Deficiency Syndrome)

AIDS is a disease in which body's immune system, the system which protects our body against infections, is destroyed. The body becomes unable to protect itself against many other diseases i.e. immune deficiency develops.

Causative Organism

The causative organism is a virus called HIV (Human Immune deficiency Virus).

Signs and Symptoms

The word syndrome is used in AIDS because it is a disease with many symptoms occurring at the same time. The patient may suffer from chronic fever, severe diarrhoea lasting for months, pneumonia etc. and even cancer.

AIDS is usually transmitted by

- Sexual relationship with an infected person.
- Blood transfusion from infected person.
- By sharing contaminated injection needles. For example when drug addicts share their used syringes.
- By using contaminated razors, surgical and dental instruments etc.
- Virus may pass from the infected mother to the foetus during pregnancy.

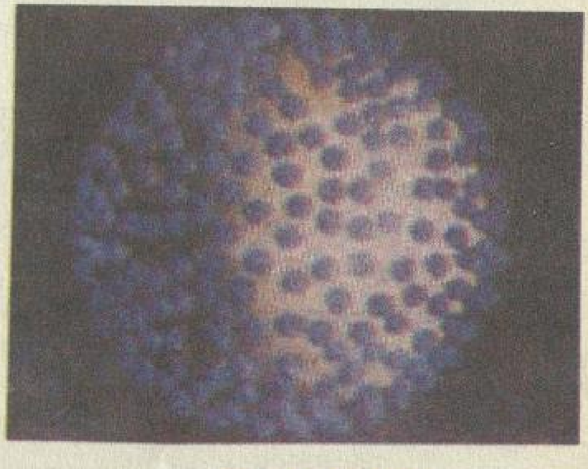

Fig. 20.22 HIV

Prevention and Control

Aids can be prevented by talking following measures

- By keeping to one's own sex partner.
- By avoiding drug abuse as drug addicts share hypodermic needless.
- By using disposable syringe.

- By sterilizing the medical equipment before examining the patients.
- By avoiding the sharing of instruments that cause lesion and be contaminated with blood e.g. toothbrushes and razors.
- By using carefully sterilized surgical instruments / equipments.

KEY POINTS

1. Genetic engineering is the manipulation of genes at will, and has great application in agriculture, chemical, drug industries and medicine.
2. Fermentation process carried on by bacteria and fungi is useful in the production of food e.g. yogurt, bread, cheese, alcohol etc.
3. Bacteria are helpful in improving soil fertility by fixing atmospheric nitrogen.
4. Biology is playing its role in the economic development of man.
5. Dairy, poultry, forestry, agriculture and many other related fields, are being improved.
6. Microorganism such as viruses, certain bacteria, fungi and protozoan are pathogenic and are responsible for causing various diseases.
7. Certain worms such as roundworms, flat worms thread worms and liver flukes are parasites and cause different diseases in man.

EXERCISE

1. Fill in the Blanks

(i) Genetic Engineering is a technique used to transfer Genes from one ________ to another.

(ii) Most bacteria are saprophytic decomposes, meaning that they ________.

(iii) ________ is an important component of proteins.

(iv) *Ascaris* is a ________ worm, which lives in ________.

(V) Mean of transmission of a pathogen from an infected person to a healthy person is called ________

(vi) Honeybees are ________ consisting of queen, drones and workers.

(vii) Forestry is the business of cultivating ________.

(viii) Over-croweded, humid and dirt conditions promote the spread of ________

(ix) Mosquito in the life cycle of plasmodium is an ________ host.

(x) Sericulture is the production of silk by the activity of ________.

2. Write whether the statement is "true" or "false". Correct the statement if it is false.

(i) Thyroxine is a hormone which controls the amount of sugar in the blood.

(ii) Role of biotechnology in the production of food is based on the process of decomposition.

(iii) Human population grows when more people die each year than are born.

(iv) Life cycle of tapeworm involves three hosts.

(v) Causative organism of AIDS is a bacterium.

(vi) Contamination of the environment with waste products and other impurities is called pollution.

(vii) BOD is a measure of water pollution level due to sewage and other organic matter.

(viii) People who can not make insulin suffer from Diabetes mellitus.

2. Each question is followed by four options. Encircle the correct answer.

(i) To which group(s) microorganisms which bring about Nitrogen fixation in root nodules of Legumes belong to?

(a) Protozoa and bacteria
(b) Fungi and bacteria
(c) Bacteria
(d) Fungi

(ii) Which organism transmits parasites from one host to another?

(a) Bacterium (c) Pathogen
(b) Vector (d) Virus

(iii) Role of biotechnology in the production of food is based on

(a) Respiration
(b) Decomposition
(c) Digestion
(d) Fermentation

(iv) Mutualism is an association between two individual in which;

(a) One partner gets benefit and other is harmed
(b) One partner gets benefit and other is neither harmed nor get benefit
(c) Both partner get benefit
(d) Both are harmed

(v) Which form of drug abuse involves most risk of infection with the HIV (AIDS) virus.

(a) Cigarette smoking
(b) Using alcohol
(c) Injection of heroine
(d) Taking too many aspirin

4. Name the organism which;

(a) Causes malaria

____

(b) Spreads malaria from person to person

____

(c) Causes AIDS

____

(d) Is responsible for cholera

____

(e) Causes Ring Worm

____

5. Which of the following terms A-E are associated with a-e:

A. Sulfur dioxide D. Pollution
B. Ozone layer E. Pollutants
C. Sewage

(a) The process by which harmful substances are added to the environment.

(b) Waste organic matter that causes water pollution.

(c) Exhaust of motor vehicles releases these harmful substances into the atmosphere.

(d) This acts as a shield preventing too much Ultra Violet rays from reaching the earth.

(e) This gas is produced by the burning of low-grade oil and coal.

6. How does recycling of used materials help to conserve the Environment?

7. Write a note on air pollution.

8. What is green-house effect?

9. What is the role of biotechnology in food production?

10. Write a note on nitrogen fixation.

11. State the importance of antibiotics.

12. Discuss the following:

(a) AIDS
(b) Cholera
(c) Measles

Read it after life cycle of flowering plant on page 78 (before Figure 16.9).

Male Gametophyte

The microspores are produced in the pollen sacs of anther of stamen, by meiosis. These microspores mature into pollen grains. The pollen grain germinates, after it falls on the stigma of the carpel. Pollen grain has a generative nucleus, and a tube nucleus. Generative nucleus divides to form two sperm nuclei. Tube nucleus forms a long pollen tube, in which two sperms move. This structure, having a pollen tube with two sperms and one tube nucleus is the male gametophyte.

Female Gametophyte

The ovary of carpel may have one or more ovules. Ovules is a megasporangium with outer integuments which have an opening called micropyle. The megaspores are produced by meiosis in the ovule. Out of four megaspores formed, only one gives rise to female gametophyte. The megaspore under goes three mitotic divisions, which result in 8 - celled female gametophyte. Three of these cells are present at one pole and the three others at the opposite pole which are, the egg, and two synergids or help cells. The central cell of gametophyte contains two polar nuclei.

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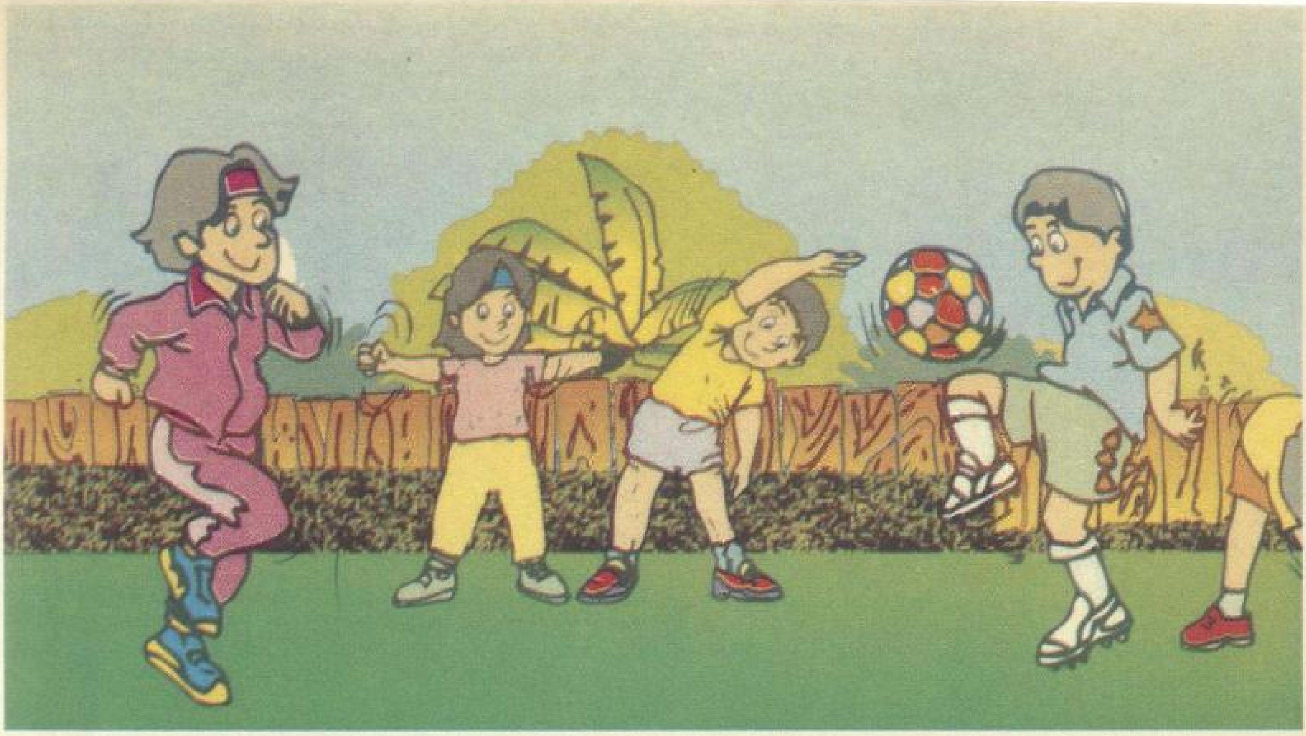
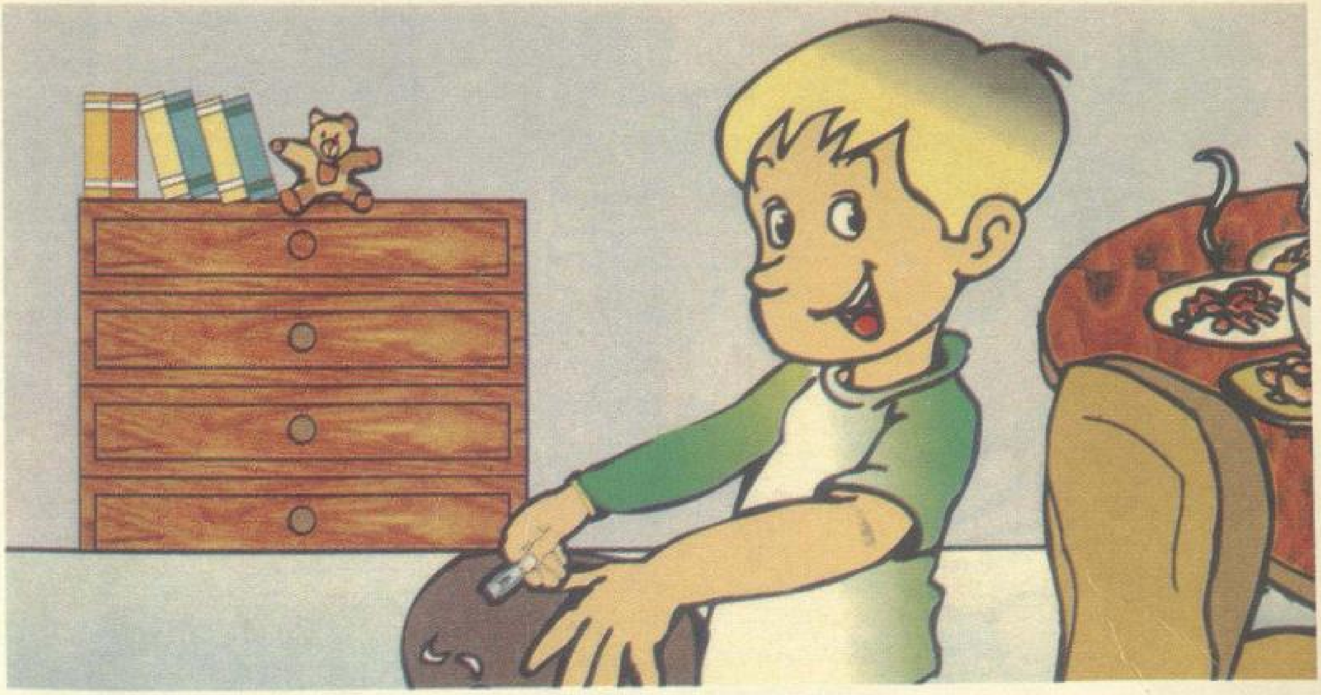


Exercise is essential for the body; it makes us feel good all through the day.



Clip your nails on time so that dust does not get stuck in them.
Also, wash your hands and feet regularly.

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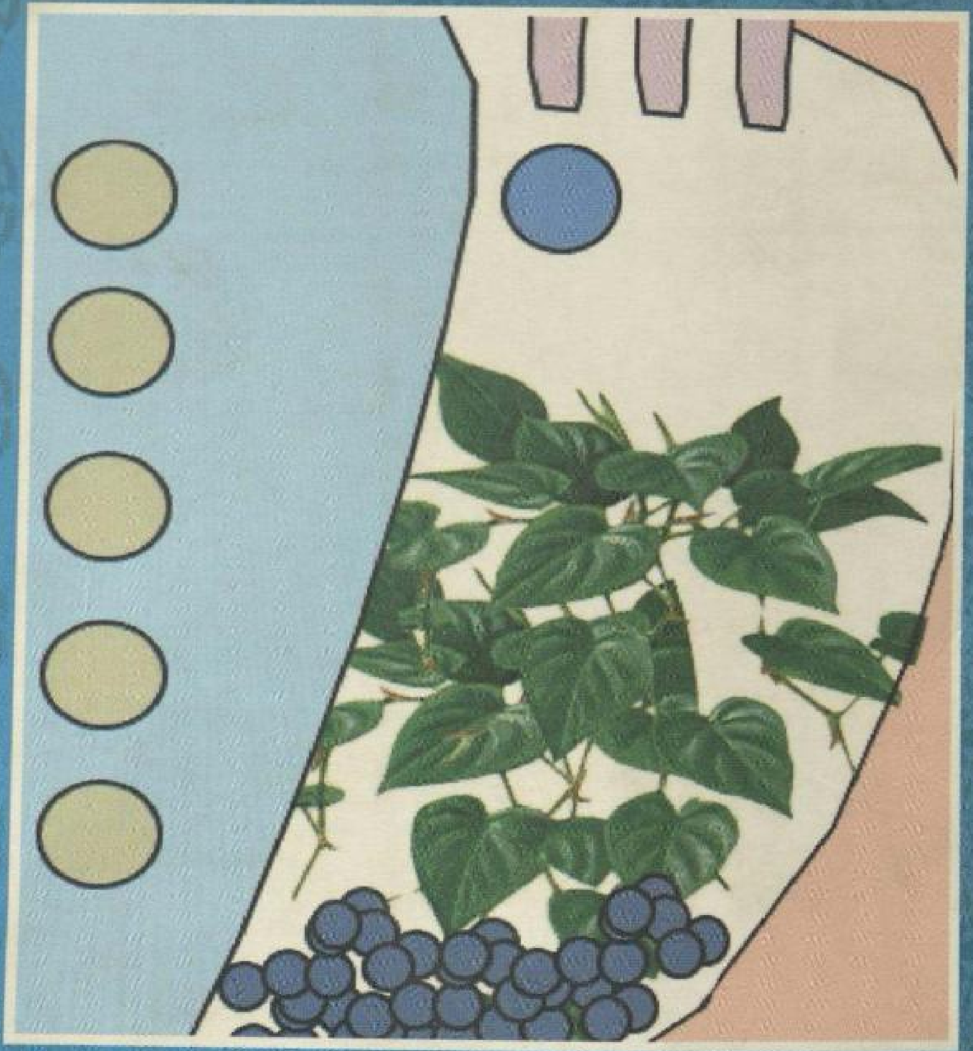

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